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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The Conference.

The annual Conference of the Institute of British Foundrymen which opened yesterday at the Agricultural Hall was characterised by the excellence of the foreign exchange papers. Mr. Lenz's lecture on "Quality in Quantity," submitted on behalf of the American Foundrymen's Association, showed in the clearest possible way that whilst quantity production methods demand less skill from the craftsman, they enlist the closer attention of the management, and this intense application of ingenuity by the direction results in the production of truly high-grade castings. We do not believe that this replacement of art by science is at all against the best interests of the industry, but there must be an orientation of thought—concentration by the practical man from individual mould construction to the consideration of a larger problem of which this is but one important factor. Transport, uniformity of mould and core shape, control of the physical and chemical properties of the metal, sand and other raw materials assume greatly enhanced importance under quantity production methods.

One phase of these considerations was dealt with by Monsieur Lemoine in his Paper on "Foundry Sands," submitted on behalf of the French Association Technique de Fonderie, who showed quite clearly that some types of wasters can be anticipated and prevented by the commonsense application of sand control.

The fascinating subject of high-duty cast irons was dealt with in an admirable *exposé* of the present position by Monsieur Piedboeuf, of the Belgian Foundrymen's Association. It represents a type of work which could usefully be repeated at frequent intervals, say, biennially. Other foundry subjects could be similarly treated, as nothing is more refreshing than an exact statement of the position in which any particular subject stands. Such studies indicate which lines appear to offer the most promising fields for research; prevent the same ground uselessly being retraversed: show where agreement has been reached, and generally crystallise the subject under review so that clarity of thought is more easily induced.

A feature of yesterday's meeting was the number of foreign foundrymen present. Whilst the Convention makes no pretensions to being an international one, the organising committee felt very flattered, and it was only a sincere desire to do nothing which would detract from the importance and success of the Detroit Convention which prevented them from sending omnibus invitations to the foundry technical associations of the world. To-night, however, they are to be honoured by a banquet offered by the organisers of the Exhibition. Every effort was and is being made to afford to them the facilities offered by the Convention, and for any disappointments, we crave, on behalf of the Executive Committee, a maximum of indulgence, because although not superficially evident, the strike has been of such a character that at one time the difficulties imposed seemed to be insuperable. This Committee, too, desires to express its deep indebtedness to those who by subscriptions, by the throwing open of their shops, or by their personal endeavour, have lightened in so large a manner the work imposed in arranging this Conference.

A Few More Exhibits.

DAVID COLVILLE & SONS, LIMITED.

Glengarnock Iron and Steel Works, Glengarnock.

One would imagine that it would be difficult to make an interesting exhibit of pig-iron, but this has been achieved with undoubted success by this concern. They show, for instance, micrographs of low carbon pig-iron illustrating an even graphite structure throughout the whole cross section of the pig. Other micros show that for certain qualities the matrix is wholly pearlitic in character. Desiring to have some polished paper weights for exhibition, and the works being wholly closed down owing to the strike, they persuaded a client to prepare some from a consignment in stock. These present an unblemished and highly-polished surface. Other interesting exhibits are a well-cut square thread turned on pig-iron; a roughly-proportioned charge, showing the amount of ore, coal, coke and limestone used. Then there are several very interesting charts showing the raw materials used, the product and the innumerable by-products. Other exhibits are sectioned castings of the most complicated character, made from Dalzell pig-iron, and fractures of this iron as made for both Diesel and automobile engine cylinders. The stand is in charge of Mr. P. A. Abernethy, the blast-furnace manager, assisted by the works chemist. Both being high-grade technical men, the stand is well worth a visit. Mr. H. G. Somerfield, of Charterhouse Chambers, Charterhouse Square, is the agent for this iron for London and the Southern Counties.

ANGLO-AMERICAN STEEL COMPANY, LIMITED.

66, *Victoria Street, London*, S.W.1.

One of the most interesting exhibits is one devoted to the direct production of steel from iron sand. It is presided over by Madame Da Silva, who has created the development. Samples of both raw material and finished products are shown in the shape of rails and various sections. Before treatment in the electric furnace in Sheffield, the sand is magnetically separated in Birmingham. The claims for the mechanical qualities of the steel are supported by numerous tests carried out by the Sheffield Testing Works. The direct production of steel has always been in the eye of the metallurgist, and this new process will be watched with the greatest interest by all steelmakers. An invitation is extended to investigate the process at their Sheffield Works.

SELSON ENGINEERING COMPANY, LIMITED.

26-28, *Charles Street, London, E.C.*1.

An exhibit of Naxos-Union grinding wheels should be of particular interest to the iron founder owing to a newly-discovered method of bonding carbide of silicon (carborundum), which allows of an increased capacity for fettling and general iron foundry grinding.

The Naxos-Union special impregnated wheel for the dressing and fettling of the aluminium castings eliminates all the troubles originating in filling and clogging, and thus offers a fast free-cutting face to the work being ground from start to finish.

There is also shown an improved magnetting machine for separating iron and steel chips and filings from brass, which is provided with a large number of magnets. By a mechanical arrangement in the throat of the funnel, only such a quantity of filings as can be thoroughly separated can pass on to the drum at a time.

A friction disc-cutting machine is also shown, and has been specially designed for use in foundries. Friction disc-cutting machines have for many years been used to great advantage for cutting all kinds of rolled material. A special machine has now been produced especially intended for use in iron and steel foundries. This new machine eliminates the difficulties occurring by cutting brittle material and in dealing with pieces of awkward shape in the modern foundry. The machine is suitable for a wide range of work, and is especially suitable when the work has to be done in batches, which is of equal importance in the modern foundry as in the machine shop. In designing great importance was attached to producing a machine suitable for cutting at any angle. A few lever movements suffice to set the machine for any work in its capacity. The rapidly revolving steel disc is not toothed but only made rough at the edge. This presses against the material and the friction causes intense heat; the particles of the material are made red hot so that when the disc feeds further to the material it is easily parted.

The stand is in charge of Mr. Narborough and Mr. Asburey.

Exhibition News.

On Monday there was an official visit by the Sheffield Ganister Association. They showed a good deal of interest in foundry portable mould-drying stoves, which they thought applicable for the burning of refractory bricks. At a tea offered by Messrs. F. W. Bridges & Sons, Limited, over which Mr. Job Holland presided, they were officially welcomed by Mr. V. C. Faulkner, the President of the Equipment Association.

* * *

The stand of Messrs. T. E. Gray & Company, Limited, has created much interest, as it consists of a quarry, complete even to a derelict hat in the corner, which some wag has labelled "sold." We suspect Jim, who is also on exhibit.

* * *

Some castings made without feeding heads sectioned to show a perfectly sound fracture are a feature of the technical exhibit.

* * *

On the stand of the British Cast Iron Research Association are a series of similar fractures of pig-iron having a large range of composition and a second series of approximately the same composition, but a very wide range of fractures. They illustrate Mr. Yate's paper on this subject.

* * *

The most appreciated visitor to the Exhibition was the foundry owner who last Saturday brought his manager, his foreman and his buyer—the last-named being complete with his order-book.

* * *

Messrs. Bagshawe & Company, of Dunstable, sent a large number of their foundry staff to the Exhibition last Saturday. Some of the exhibitors were astonished at the technical knowledge possessed by the girl core-makers.

* * *

Messrs. J. Stone & Company, of Deptford, and the Suffolk Iron Foundry have also sent large numbers of workpeople.

* * *

A splendid sign of this exhibition is the friendliness of the various exhibitors due no doubt to their connection with the Foundry Trades' Equipment Association.

* * *

The action of the organisers in supplying all the officers of the Equipment Association and the Technical Advisory Committee with souvenir medals was highly appreciated.

* * *

The object of the Pig-Iron Exhibit is to show the composition and characteristic fracture of iron, a typical brand coming from every important iron-making centre in Great Britain.

* * *

One of the most pleasing features of the show is the interest which the moulding machine manufacturers are taking in internal transport, and interesting developments are expected.

* * *

Taking the Exhibition as a whole, it contains the most complete collection of British pig-irons ever exhibited under one roof.

* * *

The linking up of the sand-preparing plant and moulding machine plant is a pointer well worth considering.

* * *

The most popular stand at the Exhibition is to be found near the exit of the large restaurant.

THE ADDRESS of the Consumers Company, Limited, makers of the "Concor" super core-binder, is 37/41, Gracechurch Street, London, E.C.3, and not Eastcheap, as stated in their advertisement last week.

International Foundry Trades Exhibition.

Opening Ceremony.

The Fourth International Foundry Trades Exhibition was opened on June 10 at the Royal Agricultural Hall, Islington, London, by Sir Robert Hadfield, Bart., F.R.S. Previously Sir Robert had been conducted round the Exhibition by Mr. V. C. Faulkner (President of the Foundry Trades Equipment and Supplies Association) and of the members of the Council.

At the opening ceremony, which took place in the centre of the Hall,

MR. V. C. FAULKNER, before calling upon Sir Robert Hadfield, said he was exceedingly sorry that the President of the Exhibition, Vice-Admiral Sir George Goodwin, was not able to be present, and nobody would be more sorry than Sir George himself. Had Sir George been present it was quite certain that he would have said they were exceedingly fortunate in having present Sir Robert Hadfield, who was Chairman of a firm which possessed the largest steel foundry in the world. That statement was taken from an American source, and therefore there must be reason to think there was some truth in it. (Laughter.) It did not matter, however, whether the Hadfield foundry was the largest in the world or not, but of one thing he was perfectly certain, and that was that no works in the world was controlled by a more erudite Chairman than Sir Robert Hadfield. Sir Robert Hadfield had put before the metallurgical industry many revolutionary inventions in the past, such as manganese steel and silicon steel. Recently Sir Robert had become an ironfounder, because of his association with the Bean car, and it was to be hoped that there would be close co-operation between the Research Department of the Hadfield firm and the manufacturers of the Bean car, and that Sir Robert would be able to devote some portion of his valuable time to the study of cast iron in a similar manner to that in which he had devoted himself to the study of steel. In that event we could look forward to some epoch-making inventions in a new field. In his recent speech to the shareholders of Hadfield's, Limited, Sir Robert had reminded his audience that in America they were putting 2½ h.p. at the elbow of every workman, but there was one exhibit in the Exhibition which, instead of putting 2½ h.p. at the elbow of every workman, put a gramophone spring to do the work, so that perhaps it would not be necessary to give the workman such large amounts of power in the future. (Laughter.) He was exceedingly pleased, continued Mr. Faulkner, to see that the Exhibition was practically ready, with the exception of one stand, and that was a stand which he had the honour to control. (Laughter.) That, however, was due to difficulties with the Customs and Bills of Lading and things of that kind in which he had had but little experience. Nevertheless, on behalf of the Foundry Trades and Supplies Association, he congratulated the organisers, and the people who had taken space, on the energy they had displayed in getting the Exhibition ready under circumstances which could not very well be worse than they are. Finally, Mr. Faulkner reminded his audience of the vital part played by the foundry in the construction and maintenance of modern civilisation, and gave instances to show how from the early morning cup of tea right through the day to the switching off of the light preparatory to retiring at night, castings are essential for the easy performance of every action. When people spoke of key industries they would on investigation find that at the back of any key industry was the foundry every time, and he appealed to the Press to help the trade and the nation by pointing out that the key of key industries is the foundry industry. Mr. Faulkner then called upon Sir Robert Hadfield formally to open the Exhibition.

SIR ROBERT HADFIELD, in formally declaring the Exhibition open, said:—I have been asked by the Organising Committee to attend here to-day to help on the excellent work in connection with this International Foundry Trades Exhibition, with which, I understand, are allied the Institute of British Foundrymen, also the London Convention and International Foundry Congress, 1926. I have now much pleasure in declaring the Exhibition duly open, and most heartily wish it a very successful run. As my hard-working friend, Mr. Bridges, has organised the Exhibition, I am sure its work will have been done well and completely. I have looked over the description of the many and most useful exhibits, which seem to me excellent and informative. In view of the difficulty of these parlous times, it is wonderful how this big show has been got together so satisfactorily.

Recent Progress.

The foundry is a noble art and profession. Probably it was even known before the age of the smith. In those early days it was perhaps much more easy to make molten metal and pour this into moulds than to produce iron and steel in its forged form. The profession of the foundryman throughout the world now covers a very wide field, and the industry is carried out on an immense scale. Some foundries I know of have not merely so many thousand square feet of moulding area, but in one case I have in mind there is a total space available under one roof of six to seven acres, which would open the eyes of our forefathers. At any rate, this shows how immensely rapid has been the progress of the foundry, whether relating to non-ferrous materials, cast iron or steel. When nowadays we look at heavy, large and complicated machinery, often weighing hundreds of tons, in which the product of the foundry known as castings, whether of steel or iron, or both, form an important part, it is seldom realised how much human energy, both physical and mental, has been expended in producing the parts making up these important and useful combined productions of the foundryman and the engineer. We take for granted to-day what our forefathers would have regarded as nothing less than a miracle. The design of the castings in such engineering productions, many of them of most complex shape, requires much ingenuity, skill, knowledge and experience. Apart from the draughtsman himself originally designing the part for the engineer, the founder's first aide-de-camp, the pattern-maker, has much to think over and consider, much to correct, to add a fillet here, a bracket there. Simple as all this may seem, it has to be thought out in order to obtain in a successful and satisfactory form what we call "the casting." There is, too, one serious difficulty which is constantly haunting the foundryman, and its significance is a nightmare to him. It is represented by the word "wasters." Whilst with good management these can be largely reduced, yet there is always the liability.

The foundry covers a multitude of applications, dealing with all kinds of metals and their combinations; for example, there are the foundry moulds and casting work necessary for metals with low melting points, say, up to a few hundred degrees Centigrade; next, moulds for non-ferrous products up to about 1,000 deg. C.; moulds for cast iron reach still higher temperatures, about 1,200 deg. C. to 1,300 deg. C.; and, finally, at the top of all these, there is the "king of all," steel castings, requiring casting temperatures of 1,500 deg. C. to 1,550 deg. C. Each of these branches of the foundry art requires its own skilled men. The knowledge of the moulder in, say, non-ferrous castings is useless for the founder in steel. The methods and materials, and the sands employed by the steel founder must be entirely different to meet the higher temperatures I have just mentioned. If steel were poured into a mould prepared for a non-ferrous or cast-iron product, it would be blown to pieces, or even if that did not occur the castings made would be so scabbed as not to be usable or of the slightest service or practical value.

The foundryman is a handy man, and I remember during the great war several very striking instances of this. The Government required in a great hurry certain parts of their battleships and cruisers covered with special armour, which in the

ordinary way it was quite impossible to get quickly enough from the armour makers, who were already too fully occupied. So they turned to the steel foundryman, and in this case particularly to my own firm in Sheffield, saying, "Can you mould and cast for us this and that object, chiefly for warship equipment, including conning towers weighing some 30 tons apiece, tubes, armoured hoods and shields. I am glad to say that the Sheffield foundryman buckled to and did those important jobs in most excellent fashion, and quite up to time. Thus the Government obtained those necessary protective products of the required type, amounting eventually to thousands of tons, at a minimum expense and in the shortest possible time. All thanks were due to the aid rendered by the steel foundryman. Not only were these articles furnished in a satisfactory manner and in an incredibly short space of time, but, in addition, it must not be forgotten that every one of them had to be of such high quality as would withstand the attack of severe gunfire—that is, the quality of the product had practically to equal that of rolled and forged steel. For example, quite large calibre projectiles could be fired at this cast armour of ours, and they would splinter or glance off harmlessly. Now, alas! all this is forgotten; Sheffield, where the work was undertaken, has its out-of-work population of some 25,000 now increased to about 45,000.

Hydraulic Cylinders.

Another instance of most highly technical work in the steel foundry is represented by a class of work my firm turns out, which there are few, if any, others able to produce in the way we do. I refer to hydraulic cast-steel cylinders, some 32 ft. in length, as used in cotton presses, to take rams not more than 8 in. in diameter. The walls of these hollow cylinders are only about 1½ in. in thickness, and yet have to stand a pressure of three to four tons per square inch without showing the slightest sign of weakening. In fact, this is the working pressure to which they are subject year in and year out. When it is remembered the mould for these cast-steel cylinders must be made 6 in. to 7 in. longer than the article produced, those foundrymen present know very well how exceedingly difficult it is to take care of the contraction of this complicated mould, also at the same time to obtain steel absolutely free from blow-holes or faults of any other description. Yet it is done very satisfactorily in this and other directions. Before concluding my remarks regarding the foundryman himself, may I add that we have always had the most excellent relations with our Moulders' Union and the many hundreds of moulders we employ. Why workers such as these should all be out doing nothing because Mr. Smith and Mr. Cook will not sit down round the table and settle on reasonable lines Heaven only knows. If we cannot have national settlements, let us try district settlements.

Now we are in the thick of this terrible coal crisis, I would like here to ask a little conundrum: Why is foundry organisation very much like the Government? Because the foundryman is trying to mould castings and the Government is trying to mould events and public opinion, not apparently very successfully just now. As regards the moulds themselves, we know the British foundryman can make excellent ones and obtain from them satisfactory castings. Let us hope the Government will before long make a good sound job of the miners' dispute—not an easy task, but surely it can be done. It seems to me there is, at any rate, one way out. Why should not the employers and miners form a panel outside those immediately concerned, to whom the whole subject could be referred, and whose decision should be final and binding on both sides? I cannot reiterate too strongly the terrible position in which the industrialist is now finding his works, his men, and himself. A settlement must be made quickly.

When speaking of the miners, let me say that during the war how much we all admired their bravery at the Front. Do not let us overlook this in these piping times of peace. We know how they fought in the trenches against the common enemy, and every credit is due to them. We also want to give them credit even now in this different kind of fight, in which they no doubt believe they are in the right; but that, alas! does not help the country, whose interests are being paralysed, and to such a degree, that it is very hard to realise what is going to be the outcome of this terrible stoppage, resulting to a large extent through misunderstanding on both sides. Only yesterday the miners have been telling us that the price of coal must be advanced 3s. per ton. I ask them in all sincerity how firms like my own, who use weekly thousands of tons of coal and coke, are going to face this extra charge. We steel men, we engineers, and other industrialists, already find it almost impossible to meet the competition in many lines of work coming from the Continent, where labour is paid at a much lower rate and works much longer hours. In my own firm's case, such extra cost would mean a dead charge on us of some £15,000 to £20,000 per annum. This is altogether an impossible advance in cost to meet, and at the same time retain our business. May I throw out a suggestion for the consideration of Mr. Smith and Mr. Cook on the one hand and the Employers' Association on the other? A short time ago I asked a little friend of mine, aged eleven years, what she thought about the strike and what could be done to bring about a resumption of work. Her reply was, let the miners work half an hour longer and let them get more wages per day.

Industrial Situation.

We have met at a very grave time in our industrial history. To-day there are out of employment nearly 1¾ millions of workers, something like 60 per cent. to 70 per cent. more than was the case six or seven weeks ago, when there seemed to be a turn for the better, and the unemployed were going down considerably in numbers. We know, unhappily, what has brought this about, first the general strike, and now the almost greater strike of the coal-miners. In my return from the Sheffield Employment Exchange of the Ministry of Labour received this morning, there are now no less than 45,756 men, women, boys and girls on the unemployment list of the Exchange. The position is not only unfortunate, but an exceedingly grave one. Before long the greater part of the country's industries will be brought to a complete standstill, then where shall we be? I do not believe this is for one moment the will and desire of the British workman. I cannot help thinking that at the bottom of some of this trouble is the question of the Communistic influence, and we ought to set our faces against these horrible doctrines which are brought from abroad. I cannot see what possible good they are doing to the working class, and I do hope the Government will before long decide to take a firm stand. This waving of the red flag and this singing of the Red Flag cannot do any earthly good to the nation. I only know of one flag which has done any good to this country, and that is the Union Jack—(applause)—which is good for me, and I hope we shall not forget to rub that in. This attempt to cripple the nation is neither loyal nor patriotic, and I wish the miners could only see and understand what they are doing in their attempts to wreck their own industry.

Speaking personally, I think it is unfortunate the Government did not take earlier steps to try and meet the present situation, of which they had ample warning. More negotiations ought to have been taking place months ago.

In an article I wrote for one of the papers early this year I ventured to call attention to the fact that the time was fast approaching when, if the two parties, Capital and Labour, could not agree, an effort should be made to establish an Industrial Council, a body of quite different constitutional nature from any yet brought forward or tried. This body should be comprised of a comparatively small committee of employers and employed, elected by the nation, and independent of any existing body. To it should be referred all disputes of the present nature. Meanwhile, no stoppage of work should take place on the part of the workman or lockout on the part of the employers.

On a small scale the system I advocate was put into practice with most admirable results during the trouble in the Greater London electric supply industry a few months ago. Strike and lockout action on either side was averted, as the result of

a long conference held at the Ministry of Labour. Of the twelve men composing this conference, six represented the employers and six the Trade Union workers concerned, and there was an independent chairman.

Finally, if all these various federations of either side cannot come to an understanding, that is, neither the employers nor the employed seem to be able to get together, also if the Government will not interfere, why should not each side choose an umpire to see if there were not points upon which common ground could be reached? There would be no compulsion about the decision of the umpires, but surely such a procedure would largely help to take away the bitter feeling which now exists and is growing still worse.

Vote of Thanks.

MR. A. S. BEECH (Vice-President of the Association), proposing a vote of thanks to Sir Robert Hadfield, said there was no finer foundryman in Great Britain than Sir Robert Hadfield. The calls upon Sir Robert's time were enormous, and speaking on behalf of the Council of the Association he wished to say how they appreciated to the full the kindly action of Sir Robert in coming to open the Exhibition. Speaking of the Exhibition itself he said it was a small but interesting one in many ways. In the first place, it was the first International Foundry Exhibition held under the auspices of the Foundry Trades and Equipment Supplies Association which was formed about 18 months ago with the idea of enabling the manufacturers and suppliers of foundry plant and equipment to have some sort of control in saying when and where foundry exhibitions should be held. The Association had already served several useful purposes, but it did not attempt to control prices. One of the useful things which had been attained by the formation of the Association, however, was that competitors in the trade had got to know each other very much better than they previously did, and that a much more friendly spirit had been introduced into the trade than had ever been the case before.

MR. H. WINTERTON (Vice-President), who seconded the vote of thanks, said that if only some of the ideas suggested by Sir Robert Hadfield in his speech could be put into practice, we should have a solution of many of the difficulties from which the country was suffering at the present time. Those responsible for the Exhibition felt they were indebted to Sir Robert for having given them such a practical illustration of his interest in their trade.

The vote of thanks was carried with acclamation.

SIR ROBERT HADFIELD briefly acknowledged the vote of thanks and an adjournment was made for luncheon.

Inaugural Luncheon.

At the inaugural luncheon, over which Mr. Faulkner presided, the following were among those present:—Sir Robert Hadfield, Mr. A. S. Beech, Capt. R. B. Crewdson, Mr. R. Genders, Col. M. K. Hezlet, Mr. Barrington Hooper, Sir W. J. Larke, Comdr. C. L. Long, Mr. W. R. Long, Dr. H. Moore, Mr. J. G. Pearce, Mr. V. E. Pullen, Mr. H. G. Sommerfield and Mr. H. Winterton.

After the loyal toast,

SIR WILLIAM LARKE proposed "Our Principal Guest." He said it would be presumptuous on his part to commend such a toast, because their principal guest was Sir Robert Hadfield, whose name was a household word throughout the metallurgical world. He well remembered in 1904, as a humble member of the Iron and Steel Institute, being present when Mr. Andrew Carnegie presented Sir Robert Hadfield with the Bessemer Medal, the Blue Riband of the British iron and steel industry. That was a long time ago, but Sir Robert had attained an eminence in the metallurgical world which merited that very great distinction at that time. Since then, his name was synonymous with that of steel; he had been honoured by every ferro-metallurgical country in the world and by all the scientific societies connected with the industry, therefore it was a privilege to submit the toast of Sir Robert Hadfield as the principal guest on this most important and auspicious occasion in the foundry industry. He could do nothing by way of commendation of the toast, but could only submit it, feeling it a great honour to have had the toast entrusted to him. He would like to say, however, that Sir Robert Hadfield typifies that very fine class, the British industrialist. We, in this country, indulged far too much in that very expensive form of vanity, self-depreciation, and when he remembered, as he did—being privileged to be in a position to observe—the efforts of British industry during the war period and the efforts of Sir Robert Hadfield's firm, perhaps in particular, to some extent, when he remembered the extraordinary achievements of that firm—some of which Sir Robert had already referred to—he felt nothing but confidence for our future if we would only come to our senses and remember that aspirations cannot be achieved when they come in conflict with ordinary economic laws. In submitting the toast, he wished Sir Robert a long and happy future in which he might be able to add still greater achievements to those which he had the honour to see behind him to-day.

SIR ROBERT HADFIELD, acknowledging the toast, said it had been proposed in far too flattering terms, because he was only a humble worker like the rest, and was prepared to do his best in his day's work and endeavour to add a little to the knowledge of the world. Sometimes there was a little tendency to think that we should all the time be making startling inventions, but it did not fall to the lot of the ordinary man to do this, and we could do far more good in the world by steady progress in the manner which was exemplified by the Foundry Exhibition. The longer he lived the more he found that it was quiet and co-operative work which tells and adds to the progress of the world. He did not mean to suggest that he did not believe in individualism, because he was a very strong individualist. He believed that the individual had a better chance of making more sure progress than combinations, and he was afraid he would always remain of that opinion. He did not mean to say that forms of association were not very helpful in many lines of work, but the great advances of the world eventually would come from the individual. We had only to look round the world to see many examples of this, and there was one name which he could not help thinking was an admirable illustration of individualistic work, namely, Sir Charles Parsons. Sir William Larke had referred to the terrible crisis through which we are now passing, and it was evident that we must appreciate that this great crisis is becoming a national matter. He, personally, sincerely wished that those who had to conduct the negotiations would think a little more of the nation and a little less of the particular organisation which they represented (hear, hear). They would all have read in the papers that morning the excellent speech of Prince Henry on the previous day in opening a hospital in connection with miners, when he did not forget to tell the nation what the poor old miner had done. He felt certain that Prince Henry spoke from his heart, and it was gratifying to find a member of the Royal Family taking this interest in our national life. We also all knew the interest which the Prince of Wales took in this and similar matters, and Sir Robert recalled how, on the occasion of the Prince of Wales visiting Sheffield 2½ years ago, they were able to arrange for him to cast his own portrait with his own signature upon it. He was very glad that those present had approved of the few remarks which he himself had made at the opening of the Exhibition concerning the present crisis, because he could not help feeling that we have now got past the stage of ordinary negotiations in regard to the coal industry. The nation had every sympathy for both sides, but they did ask the parties to the dispute to realise that in quarrelling amongst themselves it was not only themselves who were affected, but every other member of the nation. In a very short time all the big manufacturing firms in the country would be at a stand-still, and then where should we be. It was a terrible state of things, and these complex labour questions certainly seemed to have arrived at a point where individuals on either side could not settle them. In these circumstances, why should there not be set up a separate organisation to be known as the "Industrial Council" (hear, hear). If that met with the approval of those present he hoped they would all talk about it, because it was only by this means that it would

be possible eventually to bring such an arrangement about. It might not be feasible, but it seemed to him that there were certain complex questions involved in these disputes which even Parliament could not solve. There was no desire to take the power out of the hands of the Government, but he felt that if there were some independent body, consisting of an equal number of representatives of employers and the workers, surely such a body ought to be capable of dealing with problems such as those provided by the coal dispute, and of finding a way out. At the present moment an impasse had been reached. Each side had practically refused to meet the other, but a settlement would have to be reached eventually, because the nation must go on, and therefore something would have to be done in the direction he had indicated before very long.

Trade Unionism and Communism.

MR. G. C. PIERCE proposed "Success to the Exhibition," and in doing so said that the last foundry exhibition to take place in London was in 1913, and everyone would agree that the period had been too long. So far as the present Exhibition was concerned, when we considered the circumstances under which it was being held, it must be agreed that the results were very satisfactory because it was common knowledge that but for the troubles through which we are passing there would have been many more exhibitors. The Foundry Trades Equipment and Supplies Association was primarily responsible for the Exhibition, and although that Association was a young body it was a very powerful one. It made itself felt in any way it desired, as he himself had found out. (Laughter.) The Association had been assisted in organising the Exhibition to some small extent by the Institute of British Foundrymen, and, in all the circumstances, he felt that the best had been done that was possible. Credit was also due to Messrs. Bridges for their part in the work. There was not much more that he could say except to refer to the terrible coal stoppage and to agree with Sir Robert Hadfield that it is a very complex question. At the same time, with all due deference to Sir Robert, he must differ from him when he said that the Communists were largely the cause of the present trouble. He, personally, had many opportunities of studying the attitude of the British workman, and he maintained that there is nothing which the average British trade unionist detests than Communistic doctrines or a Communist. The trouble was that when these people said anything in public they received so much advertisement that it was assumed they had an influence which is really entirely lacking. The Communists were really very small indeed in the power they had, and if they were not given so much advertisement in the Press they could be left to die a natural death. If a Communist were put outside any factory to sell his wares, it would only be a matter of minutes of conversation with the average workmen before the Communist would be running round the corner. So far as the present troubles were concerned, he neither had a solution nor could he contemplate one. The worst thing that could have happened was that the miners and owners should have met this week without coming to some agreement, at least for a future meeting. The only solution that appeared at all likely to be successful was that when they were put into that room they should not have been allowed out until they had come to a settlement of their differences. (Applause.)

Some of the Features of the Exhibition.

The CHAIRMAN, acknowledging the toast, said it might be necessary to look round corners to find the success of this Exhibition. One point, however, was that we might have to contemplate some of the foundries being closed down for a short while on account of the coal strike, and that would give an opportunity to foundry managers, foremen, and others to spend a longer time at the Exhibition than they otherwise would have found possible. There were hopes, nevertheless, of the success of the Exhibition in other directions. No fewer than 1,000 foreign foundrymen had asked for a copy of the Official Catalogue to be sent to them, and from that it was to be hoped that the exhibitors would receive inquiries, which was as far as any exhibition could go. An exhibition of this character could not sell goods; it could only originate inquiries, and it was up to the exhibitors to get rid of their goods subsequently, it was to be hoped, at good prices. Another factor was that invitations had been issued to overseas guests, and some hundred or more would be coming over probably in time for the Conference. They were to be entertained at a banquet. For the first time since the war, also, we should have as guests some Germans. The Stand, for which he was responsible, and which at the moment was empty —(laughter)—was to contain exhibits kindly lent by the Foundry Owners' Association of Germany, who had had at another exhibition in Düsseldorf, a large number of technical exhibits which anybody could see were the result of intense thought and consideration on the part of a number of enthusiastic individuals for a number of years. The organisers of the present Exhibition had been successful in persuading the Foundry Owners' Association of Germany to send over the cream of these exhibits. Incidentally, he would like to mention that there were included in these exhibits designs of something like 160 German foundries, and he wondered if we could get 160 British foundry owners to send along the designs of their foundries. There were also a number of diagrams which showed the right and the wrong way of doing things from the German point of view, and although some of our own experts might not agree, we could, nevertheless, all study these exhibits beneficially. There was another aspect of the Exhibition which had achieved some measure of success. The Association, over which he had the honour to preside, was originated with the idea of running an exhibition when and where the industry wanted one. At one time there was some measure of opposition—perhaps he might call it non-co-operation—from the Machine Tool Trades Association, but he was happy to say that this had been overcome, and the members of the Machine Tool Trades Association were to be allowed to exhibit at the present Exhibition, and also future ones. Whilst it was difficult to feel particularly optimistic in present times, there were signs that business must go forward. We could not stand still, and he hoped that all the exhibitors would have a really good time and be able to show a good order book when the Exhibition had closed. Mr. Faulkner concluded by saying that he had just received an intimation that the German exhibits had arrived at the Exhibition.

The final toast was "The Chairman," proposed by Mr. J. G. Pearce, who made an amusing speech in which he called attention to the fact that whereas most editors of trade journals were of a retiring disposition and were rarely, if ever, seen, not so Mr. Faulkner, who was more closely associated with the activities of the trade than the editor of any trade journal he himself knew. Not only was he editor of THE FOUNDRY TRADE JOURNAL, but he had been chairman of the London Section of the Institute of British Foundrymen, and, not content with that, he had accepted the office of senior vice-president of the parent body, and at the Conference next week he would be inducted into the higher office of president. In addition to that, Mr. Faulkner was chairman of the Foundry Trades Equipment and Supply Association, which was running this Exhibition. He knew of no industry in which the relations between an editor of a trade journal and the particular trade were so close, and it was therefore with the greatest pleasure that he presented the toast of the Chairman, and expressed the hope that these relations would become not weaker but stronger. During the next twelve months the Chairman of the Association would have a hard task, and everybody wished Mr. Faulkner all success in the enterprises in which he was taking part.

The CHAIRMAN briefly responded, and said that he had been connected with the foundry industry all his industrial life, and anything he had done in the past was but a prelude to what he hoped to do in the future.

Refractories in the Foundry.*

By H. V. Grundy and A. Phillips.

(*Continued from page* 391.)

The experience of the authors when using a wet blacking containing a high percentage of soapstone is to find slag spots containing gas holes on the face of the casting. From this it would appear that any detached blacking of this nature mixed with sand forms a fusible slag, and the holes are formed by the steam generated by the expulsion of the combined water from the soapstone. Whether or not this assumption be correct the trouble was eliminated by the use of a blacking containing a less percentage of Mg, the other conditions remaining the same.

Table VI shows various tests carried out on different plumbagos, etc. From a study of this table the materials used in the various samples can be ascertained.

TABLE VI.

Sample.	Test I.	Test II.	Test III.	Test IV.				Test V.		Fixed carbon.
				Physical properties.				Analysis.		
	Sample fused with caustic soda. Pure graphite should remain unaffected but some insoluble matter can also remain unaffected.	About 0.05 grms. sprinkled on surface of water. Good graphite should float for say 10-15 mins.	Sample shaken with acetone. Pure graphite leaves the acetone colourless. Coke remains suspended for a long time and makes the acetone greyish. Anthracite separates out more quickly and gives a faint brown coloration. Soft coal gives a deep brown colour.	Texture.	Form.	Colour.	Sp. gr.	Ash.	Volatile matter.	
Plumbago No. 4.	72.2 per cent. unaffected.	All floated	The powder settled quickly leaving the acetone slightly cloudy.	Soft and smooth.	Small flakes.	Grey black with lustre.	1.83	20.15	3.15	76.7
Plumbago No. 5.	55.0	,,	,,	,,	,,	Very black grey with lustre.	1.73	36.55	3.75	59.7
Plumbago No. 6.	44.2	Some sank slowly after 5-10 mins.	,,	,,	,,	,,	1.58	49.2	6.65	44.15
Blacking No. 7.	45.6	Some sank immediately and about 30 per cent. settled finally.	The powder settled very slowly leaving the acetone tinged dark grey.	Very hard.	Powder.	Black.	1.65	42.9	9.8	47.3
Blacking No. 8.	52.8	Some sank slowly.	The powder settled rather quickly leaving the acetone slightly tinged with grey.	Soft and smooth.	Small flakes.	Dark grey.	1.81	37.1	4.45	58.45
Sterlino No. 9.	30.7	All floated.	The powder settled rather quickly leaving the acetone slightly tinged with grey.	Harsh.	Small flakes.	Grey	1.57	59.35	4.10	36.55
Sterlino No. 10.	68.0	,,	Powder settled fairly quickly leaving the acetone cloudy.	,,	,,	,,	1.63	60.0	1.9	33.1
Charcoal No. 11.	70.0	A fairly large proportion had settled after 2 hours.	Powder remained suspended for some time. Acetone dark grey in colour.	,,	Powder.	Black.	2.10	13.95	11.72	74.33
Charcoal No. 12.	66.3	,,	,,	,,	,,	,,	2.21	14.6	11.55	73.85

From the analyses in Table VII, No. 1 is undoubtedly the best and gave the best results in the foundry. No. 2, with 2 per cent. more ash, gave less trouble in the foundry than No. 3, probably due to a higher melting point of its ash.

From the analyses of the ash one can calculate the approximate melting points upon a basis

TABLE VII.—*Plumbagos.*

Analysis.	No. 1.	No. 2.	No. 3.
Fixed carbon	92.86 per cent.	59.58 per cent.	63.65 per cent.
Volatile matter	1.34 ,,	5.34 ,,	3.10 ,,
Ash	5.8 ,,	35.08 ,,	33.25 ,,
Analysis of the Ash :—			
SiO_2	72.77 per cent.	47.08 per cent.	60.74 per cent.
SO_3	0.48 ,,	0.41 ,,	0.44 ,,
P_2O_3	0.93 ,,	0.41 ,,	0.49 ,,
Fe_2O	4.46 ,,	14.95 ,,	16.80 ,,
Al_2O_3	16.81 ,,	30.94 ,,	15.21 ,,
CaO	1.40 ,,	0.18 ,,	1.28 ,,
MgO	1.20 ,,	1.27 ,,	1.47 ,,
Calculated melting point of Ash	1300 deg. C.	1450 deg. C.	1100 deg. C.
Figure of merit	1220	940	733

* A Paper read before the Lancashire Branch of the Institute of British Foundrymen, Mr. S. G. Smith presiding.

suggested by Prost. By this means the following temperatures were obtained:—No. 1, 1300; No. 2, 1450; and No. 3, 1100 deg. C. From these figures it would appear that No. 2 with a melting point of 1450 deg. C. is the best of the three. One must take into consideration, however, that the ash content is only 5.8 per cent. in the sample No. 1 (1300 deg. C.) while in No. 2 (1450 deg. C.) it is 35.08 per cent. and in No. 3 (1100 deg. C.) it is 33.25 per cent.; in order to obtain a better comparison, therefore, it is necessary to take into account both carbon content of the plumbago and fusing temperatures of the ash.

If a figure of merit is employed consisting of the product of these two the results are as follows:—No. 1, 1300 × 94.2 = 1220; No. 2, 1450 × 64.9 = 940; and No. 3, 1100 × 66.7 = 733 which correspond to the results obtained in practice.

TABLE VIII.—*Firebricks.*

Analysis.	Stourbridge.	South Wales.	Scottish.	South Staffs.	South Staffs. "A."
SiO_2	59.46	59.10	57.34	52.36	69.74
$Al_2O_3.SiO_2$	34.39	33.17	37.41	41.20	24.38
Fe_2O_3	3.65	4.43	3.59	3.36	2.56
CaO	0.90	0.66	0.60	0.76	0.70
MgO	0.80	0.91	0.21	0.83	0.63
Loss on ignition	0.26	0.26	0.30	0.56	0.76
Alkali (Diff).	0.54	1.47	0.55	1.73	1.42
Refractory Tests:—					
Average 3 Seger cones	29	30	30	27	33
Temperature Cent.	1650	1670	1670	1610	1730

Without going into the characteristics of the basic, neutral and acid materials such as magnesite, dolomite, zirkite, alundum or carborundum, chromite, zircon, carbon, fireclay, silica and ganister, etc., it can be safely said that fireclay bricks for lining purposes give the best satisfaction. They are less expensive, easy to instal, and require less care in handling than any other refractory material. For patching and repairs, ganister is the material commonly used, but this material, in the majority of cases is carelessly prepared and applied. Ganister should be prepared 24 hours before use, and the proper consistency is reached when sufficient water has been added to cause the ganister to form a ball that does not fall apart in the hand. Before applying, it is best to remove all the slag from the lining face and wash the old surface over with slurry of the same material as is being used; this helps the ganister to adhere to the wall. Patching a cupola with wet ganister just thrown on the wall is a bad practice. It is realised that when using these materials there is a considerable expense for repairs and stoppages, and any information on this subject is greatly appreciated by foundrymen.

TABLE IX.—*Cupola Slags.*

	Chemical Analysis 6.					Blast pressure.	Erosion of lining.
	SiO_2	Al_2O_3.	FeO.	MnO.	CaO.		
No. 1	45.0	5.0	10.6	3.3	35.7	Low	Small.
No. 2	48.0	5.3	13.0	4.5	29.0	Medium	Medium
No. 3	53.3	6.0	17.0	6.0	17.8	High	High.

Refractories for the Cupola.

In discussing the subject of refractories used for cupolas it will be well to bear in mind that the materials used for the lining and patching of a cupola have been and are still unsatisfactory. Two different methods of refractory lining are used for cupolas. (1) Lining with radial fire-bricks, and (2) ramming with a refractory tamped material, either by hand or by compressed air. The question as to which is the more suitable and economical depends on local conditions and quality of material used before a conclusive opinion can be expressed.

It is an invariable principle in ceramics that basic corrosion should be met with basic bricks, and acid corrosion with acid bricks. The chemical actions that occur when melting an iron-coke-lime charge, require, in addition to considerable mechanical strength, a material which in its chemical composition offers resistance to the decomposing action. To the foundryman the special requirements of a refractory cupola lining is "the longest possible life." Acid linings are chiefly used for the cupola, although attempts have been made to use basic linings, but with unsatisfactory results.

TABLE X.—*Slag Penetration.*

Test No.	Block Material.	Coating material.	Time at 1500 deg. C.	Depth of penetration, etc.
8.	Scottish	—	1 hour	1 in. fissures filled with slag.
9.	Silica brick	—	¾ ,,	1 in. soaked right through.
10.	Ganister	—	1 ,,	1 in. ,, ,, ,, (cracked).
11.	Scottish	Ganister	¾ ,,	1 in. soaked coating and block (cracked).
12.	,,	Fireclay 50 per cent. and sea sand 50 per cent.	¾ ,,	½ in. through coating and into block slightly.
13.	,,	No. 1 cement	1¼ ,,	1/32 in. very slightly attacked coating.
14.	,,	No. 2 cement	1¼ ,,	½ in. coating and block (small cracks).
15.	,,	No. 3 cement	1¼ ,,	Coating penetrated right through 3/16 in. no penetration into block.
16.	,,	No. 4 cement	1¼ ,,	¾ in. coating and block.
17.	,,	No. 5 cement	¾ ,,	1 in. right through coating and block.

Coating Mixtures.

Material.	Composition.	Remarks.
Fireclay and sea sand	50 : 50	Small cracks when dried. Soaks.
No. 1 cement	66 per cent. alundum powder, 34 ,, lime	Appears to fuse, adheres to block.
No. 2 cement	75 ,, alundum powder, 25 ,, lime	Cracks on drying.
No. 3 cement	50 ,, alundum powder, 50 ,, lime	Adheres well to the block, appears to be a good cement.
No. 4 cement	66 ,, alundum powder, 34 ,, asbestos powder	Cracks on drying.
No. 5 cement	66 ,, alumdum powder, 34 ,, asbestos flour	Cracks on drying, coating peels off block.

Although there is not a wide variation in these

analyses it was found that No. 3 (Table VIII) gave the most satisfactory results over a twelve months' test. The chief difference between clay firebricks does not lie in the clays used or the analyses of the bricks. Grinding and mixing operations to ensure uniform and suitable material, the burning and finishing temperatures reached in manufacture, accuracy in the shape and size of the finished brick, absence of cracks and fissures and, when broken, absence of cavities, are the chief points which help to form a suitable and reliable brick.

Lining Corrosion.

With regard to the action of slag on the furnace lining, the authors have observed that thinly fluid lime slags do not attack the cupola lining to the same extent as semi-fluid and more viscous slags do. The nature and chemical composition of the furnace lining appears to be of great importance to the conditions of the slag, and it is fully realised that it is the slagging and not the resistance to heat of the lining material that governs the life of the lining. In consider-

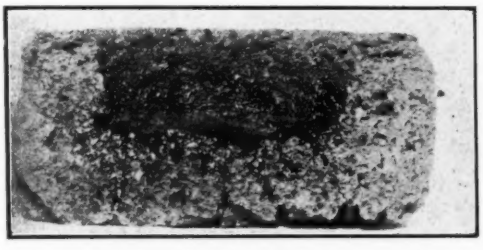


FIG. 8.—SCOTCH BRICK.

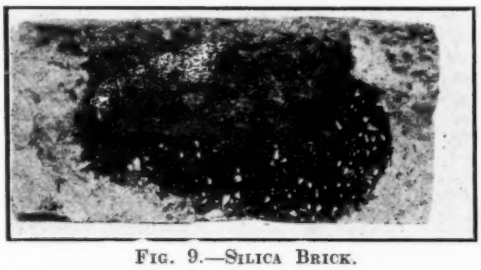


FIG. 9.—SILICA BRICK.

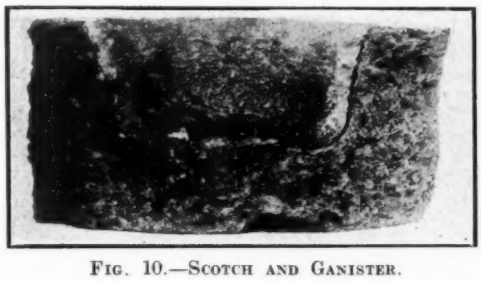


FIG. 10.—SCOTCH AND GANISTER.

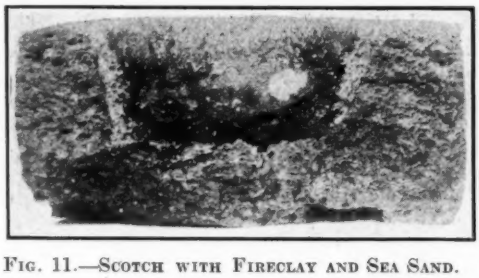


FIG. 11.—SCOTCH WITH FIRECLAY AND SEA SAND.

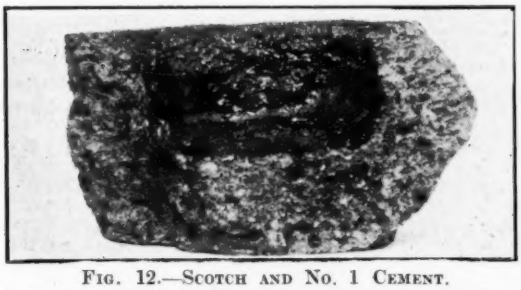


FIG. 12.—SCOTCH AND NO. 1 CEMENT.

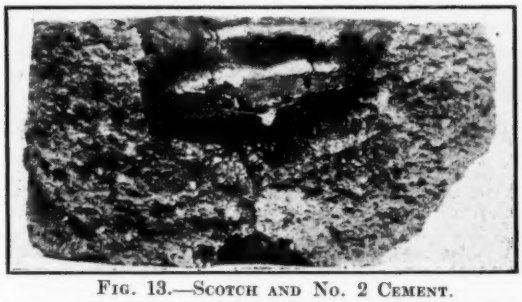


FIG. 13.—SCOTCH AND NO. 2 CEMENT.

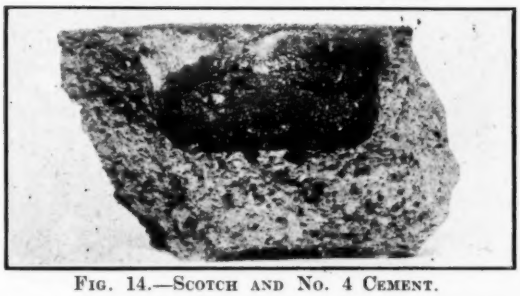


FIG. 14.—SCOTCH AND NO. 4 CEMENT.

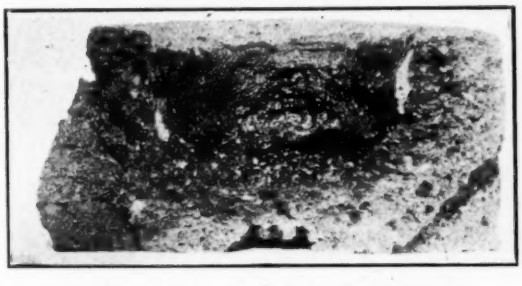


FIG. 15.—SCOTCH AND NO. 5 CEMENT.

Every foundryman knows that when lining a cupola it is more desirable to use blocks specially made for the purpose than the ordinary shaped fire brick, but the authors wish to point out here that many would be greatly surprised if they tested six of the blocks at present in their stocks for uniformity and accuracy of shape. When forming a circle with cupola blocks as commonly supplied it is practically impossible to avoid a number of wide joints, these, together with surface cracks on the face of the bricks, are the starting points for slag penetration, which appears to be the greatest difficulty that has to be overcome to obtain a satisfactory lining.

ing the action inside the cupola the sulphur in the coke burns in an excess of air to sulphur dioxide (SO_2) in front of the tuyeres. This gas decomposes and forms ferrous-sulphide and ferrous-oxide where the iron has a bright red glow, both of these constituents can be absorbed by the hot metal.

In tests carried out on electric and other furnaces with acid linings for steel manufacture, it is a well known fact that desulphurising agents will not act satisfactorily if free silicic acid is present, *i.e.*, uncombined with the clay. The purpose of a basic slag is to combine with SiO_2 and to become silicates with absorbed ferrous and

manganous oxide. The writers have not been able to carry out sufficient tests to satisfy themselves that lime combines with any free silicic acid in the lining material, which would allow more sulphur to enter the metal and also hasten the decomposition of the lining. A brick, after the burning process in the kiln, contains practically all of the silicic acids combined in the clay. Whether free silicic acid in a lining is detrimental or not is a matter that is suggested for further research, the fact is however borne out that bricks containing a fair percentage of grog have a longer life than a pure clay brick. It can be said then, that a cupola slag is a product of the transformation occurring in the cupola and consists of silicates of lime, manganous and ferrous oxides, alumina and dissolved free silica.

A good index to the possibility of lining erosion is the slag composition. This is borne out by the analyses of slags from tests carried out with varying blast pressures, other conditions in the cupola remaining constant. From Table IX it will be seen that No. 1 slag shows the least lining erosion, but unfortunately the melting rate of the metal in the cupola is too slow for economical operation. No. 2, with a blast pressure of 9 ozs. and a volume of air of 2,460 cub. ft. per min. for a 37-in. cupola appears to be the most satisfactory.

Refractory Coatings.

The technical literature of the past few years has made reference to the use of thin coatings of high refractory materials on lower refractory materials. Invariably the latter have the better bond, and are used in everyday practice. Some materials used for this purpose would appear to be technically useless, but the reactions which occur on the lining face of a cupola and the face of a mould can, in the majority of cases, only be assumed. Criticism of any experiments to increase the life of these faces should therefore be guarded. The authors appreciate the fact that it would be futile to put coatings on refractory material when the co-efficient of expansion or the shrinkage of the two materials varies materially, the authors also realise that in some cases a laboratory experiment which is the necessary guide, differs materially when adopted in the foundry. Any coating, if it is to be a commercial proposition, must improve density and the mechanical strength of the surface and thus protect the lining, against abrasion, the cutting action of the flames and against penetration by slag. Tests have been made with a view to producing a satisfactory coating material for cupola linings.

Experiments were made with a slag of No. 2 composition plus 0.5 per cent. sulphur laid in hollows cut in firebricks, some of which have been thinly covered with different refractory cements. The photographs show the depth of slag penetration. (Figs. 8 to 15.)

Table X gives a tabulated result of the slag penetration tests, together with the composition of the refractory cements used in the experiments. Comparing No. 8 with No. 9, it will be seen that a cupola slag penetrated a silica brick very rapidly. No. 12 was coated with No. 1 cement consisting of 66 per cent. alundum powder and 34 per cent. lime, which appears to be a good refractory cement. This was borne out in practice, a thin coating of this cement on the face of the cupola gave satisfactory results, especially when used over the brick joints of a relined cupola.

The authors wish to thank the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, for permission to give the paper.

Direct Steel Manufacture.

Progress in Sweden.

The Flodin Process.—According to the "Svenska Bruk," good results have attended the continuation of the experiments at the Hagfors Ironworks, Sweden, with the object of obtaining malleable iron and steel direct from the iron ore by what is known as the Flodin process. It will be recalled that, after preliminary trials carried out at the Electro-Chemical Section of the Royal Technical High School at Stockholm, it was decided to test the process thoroughly on an industrial scale at Hagfors Works, and the results of operations carried out there were described by Mr. Henning Flodin in a Paper read before the Iron and Steel Institute at its Autumn Meeting at Birmingham last year (see JOURNAL, September 17, 1925, issue). During this experimental stage an electric furnace working with 200 effective kw. was used, and one of the most difficult problems to be solved has been the construction of a large smelting furnace capable of withstanding the requisite smelting temperature. This is claimed to have been done, with the result that large-scale production has now become a possibility. A further problem was the sulphur content of the steel, which in the earlier experiments was found to be too high. It is reported that with the improved arrangements at Hagfors this defect has been remedied.

With regard to the exploitation of the process, it is stated that negotiations have been in progress with the U.S. Steel Corporation, who have displayed considerable interest in the experiments. It is also understood that financial backing has been guaranteed from this country on the attainment of positive results. The Swedish Iron and Steel Institute has granted 25,000 kr. (about £1,400) towards the cost of the experiments, while the Uddeholm Co. has also placed its resources at the inventor's disposal.

The Wiberg Method.—A further process with the same object in view is being experimented upon at Sandviken. It is known as the "Wiberg" process, after its inventor, Mr. M. Wiberg, and has also received the moral and material support of the Swedish Institute. In this process iron sponge is first produced from the lump iron ore, which is then smelted in an electric furnace. An advantage claimed for the process is the use of wood refuse for the production of reducing gases in an electric gas generator without the necessity of first turning the refuse into charcoal. Kiruna iron ore has proved specially useful in connection with this process, and excellent results are said to have been obtained. Arrangements for large-scale production are in progress at Sandviken.

The Emil Edwin Method.—Yet another direct process has recently been the subject of experiment in Norway. Its inventor is Mr. Emil Edwin, formerly connected with the Badische Anilin-und Soda, A.G. By this method the iron ore is reduced by means of gases in a rotating furnace. The gases are regenerated in a special plant. The process is not a "smelting" one in the ordinary meaning of the term, but the ore is disintegrated into dust as a result of the rapid heating, and the iron oxide particles are reduced at a comparatively low temperature. An electric ore separator is used for separating the iron dust, which is then briquetted. The electric power consumption is calculated at 2,000 kw.-hrs. per ton of iron. It is claimed that in this process it is possible to use low-quality sulphurous ore, as the sulphur and phosphorus is absorbed by the gas and does not pass into the iron.

AN order for a complete new plant for the manufacture of weldless steel tubes has been secured by the Wellman Seaver Rolling Mill Company, Limited, which is a subsidiary company to the Wellman, Smith, Owen Engineering Corporation, Limited. The value of this contract approaches £100,000, and the whole of the plant will be made in the firm's works at Darlaston, Staffordshire, which have been specially equipped for the manufacture of all kinds of steelworks machinery. The thorough modernisation of the Darlaston Works has enabled the firm to successfully compete with Continental engineers.

THE FOUNDRY, Marhamchurch, comprising foundry buildings and manager's house, with garden, was sold by public auction at Holsworthy, as a going concern, to Mr. A. Gliddon, of Chilsworthy, the purchase price being £600.

MESSRS. GEORGE GREEN & COMPANY, foundry engineers and contractors, of Keighley, have purchased from Mr. J. Pickles, Victoria Works, Bradford, the goodwill (including patterns and drawings) of the complete range of moulding machines made under the "Pickles Patents," and intend to carry on the manufacture of these machines at Keighley.

The Practical Utilisation of Apparatus for Measuring the Permeability and Cohesion of Moulding Sands.*

By R. Lemoine, Paris.

[French Exchange Paper.]

INTRODUCTION.

Although no precise information is available as to the intimate constitution of moulding sands and their behaviour in service, the experiments made in recent years have resulted in the design of apparatus for measuring the gas-permeability and cohesion at ordinary temperature with any given percentage of humidity.

In the present state of our knowledge of these sands, the methods outlined by the "Committee for Testing Sands" of the American Foundrymen's Association must be regarded as most nearly approaching the object in view. This does not, of course, imply that the principles adopted in these tests are the only ones capable of being applied to the measurement of certain complex properties of sands, because it would be quite possible to evolve other methods and devices for the purpose; but as a choice has to be made and the methods referred to above have the advantage of having been widely used for some time, and the results have been found to be sufficiently accurate and inter-comparable, at least where the necessary precautions are taken, it is the methods of the A.F.A. that have been considered in the present paper.

As stated above, these methods enable the permeability and cohesion at ordinary temperatures to be measured, while, actually, what it is necessary to know is the value of these properties at high temperatures, or, at least, those properties that have a direct bearing on foundry conditions. Nevertheless, a knowledge of the properties at ordinary temperature is of great interest to the foundryman, especially if applied in accordance with specific directions. It is the object of this Paper to explain broadly what the rules are.

The questions to be settled in foundries in connection with moulding sands fall into the following three categories:—(1) The careful selection of the mixtures intended for use for a specific purpose, both as regards their composition and the method of preparation; (2) a proper method or methods for checking the uniformity of the raw materials used in the preparation of the mixtures; and (3) a proper method or methods of checking the mixtures prepared, with a view to securing the regularity of the operations they have undergone, and constancy of properties.

I.—Control of the Mixtures.

Composition.—To enable the mixtures to be prepared quickly, considerable knowledge of the raw materials themselves is necessary. Experience of this kind is difficult to acquire, and in addition to its immediate interest, it ought to be sufficiently comprehensive, enabling subsequent problems to be tackled, especially those coming into the second category above mentioned.

It is common knowledge that the action of the metal at high temperature, or at any rate the action on the surface layers of moulds, generally consists of a drying or baking of the bond and fragmentation, more or less pronounced, of the grains. Sand, when it has been acted upon in this way, loses its cohesion and permeability, owing to the loss of some of the bonding constituents and the increased percentage of fine particles.

One of the functions of new sand which is added to old sand in order to form a mixture, consists in supplying to the whole, grains which aerate it, and fresh bonding material which, after being suitably prepared, restores permeability and cohesion to sufficiently high values.

It will thus be seen that, for a given type of output, a sort of balance must be established by means of which the composition of the mixture (proportion of new sand to old) and the preparation maintain at a constant the permeability and cohesion of the mixture during subsequent operations.

Obviously, the very existence of this balance depends upon the fresh sand available and the branch of foundry work involved. It may, however, be impossible to ensure this, especially if very complex properties are involved dependent on the intimate nature of the sands used and which are impossible of investigation in regard to such points as refractoriness, its effect on the skin of the castings and abrasion by the metal, etc.

If one examines what takes place in practice, it will be seen that it is quite possible to proceed by comparison and start from a basis that has been experimentally established. Sand control therefore amounts to adapting the composition of the mixtures and their preparation, or, in a word, to the sole determination of the equilibrium factors outlined. This should certainly be carried out in many foundries, even in those which insist that they are satisfied with their moulding sands, but which, periodically and because wasters increase, reject a portion of their old sands to be distributed in new material.

This general control is simple to achieve: it amounts to assuring constancy of permeability and cohesion, by controlling the composition of the mixture, or its preparation, as will be shown further on. The properties are, of course, measured with the aid of certain apparatus.

The question is more difficult where a new product has to be tested. It is not usual to start entirely with new sand and allow it to age in service, but this would certainly be the best way of following the evolution of the properties of the sand, and of the efficiency with which it was prepared—in a word, of studying the factors that go to make up "balance."

It would be extremely interesting and would reduce experimental work if it were possible to compare simultaneously a new material with those which are being used already and whose practical properties were, of course, known. Foundrymen are unable at present to measure directly all the factors that control the behaviour of sands in service; the chemical, mechanical and other special methods of analysis and tests are still insufficient, probably due to the part played by the intimate constitution, nor can these methods enable one to compare two sands in a practical way. It is possible, however, that the variation of certain measurable properties under the influence of a known factor forms a valuable guide. Moreover, one may conceivably do without the individual knowledge of all these elements of the intimate constitution and content oneself, for practical purposes, merely with the effects of their variation under definite conditions.

Among the discoveries made, there are one or two special features of interest, *e.g.*:—

(1) When investigating the variations in permeability and cohesion of a number of sands in terms of humidity, it is found that the resultant curves plotted are of different shape. In many cases, working with, say, from 4 to 10 per cent. of water, each of the properties passes through a maximum. In rarer cases, the maximum is only reached for higher percentages, and, for the cohesion in particular, it may only be attained at towards 15 and even 20 per cent.

The slope of the curves and the position of their maxima are points of importance. As regards the shape, the branches may be at a greater or lesser distance from the horizontal, which means that the permeability and cohesion of the corresponding sands are more or less

* A Paper read before the Annual Convention of the Institute of British Foundrymen.

sensitive to humidity. As regards the maxima of the curves, three cases may arise: the permeability and cohesion are the same with the same percentage of water; or the permeability is reached with a lower or a higher percentage of water than that of the cohesion.

All these characteristics unite in the effect to produce factors that cannot be distinguished individually, such as quality, plasticity, capacity to absorb bond, its distribution in relation to the grains, the behaviour of small particles which do not play the part of an active bond.

The very few experiments that have been carried out on these points furnish an insight into the practical interest which may be expected from the minute study and comparison of one sand with another in these respects. An example of this will be given later on.

(2) Simple and studied use of the American device for moulding the permeability test specimen shows that all sands do not behave alike when rammed. The reduction of volume they undergo under the same stress is variable. They attain, more or less rapidly, a maximum compactness, after which the blows of the rammer do not appreciably reduce their volume. Again, for the same humidity and the same ramming stress, the hardness, measured by means of the ball device designed by Mr. E. Ronceray, is just as variable as the permeability.

Here again the size of grains, their shape and all the properties of the bond intervene.

(3) By applying the hardness test indicated by Mr. Dietert,* supplemented by curves showing the variation of the permeability and cohesion after heating, in terms of moisture content, and comparing these results with those found before heating, information of a highly practical nature may be obtained.

There is hardly any need to dilate upon the measurements that might be thought out for comparing the behaviour of sands in service with properties that could be investigated before using the sands, with a view to comparing the materials against each other.

In each special case the experiments most likely to be useful should be taken, bearing in mind that those in which the moisture is the variable factor are often best, in view of the part played by moisture.

Generally speaking, the methods only involve measurements, in the cold state, of the permeability and cohesion. Sometimes special experiments are made when elaborating moulding sands, especially in the case of sand for steel foundries, where the refractory properties, with their complexities, play a part.

Although the author has had occasion to make a few tests covering these questions, it would be clearly beyond the scope of this paper to outline them, and a single example will be given later of what is possible.

Of the two parts which go to make up a moulding sand, viz., the grains and the bond, the former is generally sufficiently refractory for steel foundry purposes; but this is not the case with the latter, the function of which may be extremely variable. A sand cannot be considered as a homogeneous substance in respect to its refractoriness, and while it is true that, most of the time, the two parts cannot be regarded as behaving in distinct ways at high temperature, a certain measure of independence does exist. The bond, in particular, undergoes attrition (grésage) and in certain cases assumes a consistency such as to strengthen cohesion without altering the permeability, or, conversely, it ruins cohesion and permeability at high temperatures.

In a problem of this kind, where a lack of permeability or cohesion in the hot state was exhibited by special defects in the castings, the following experiment was made:—

Permeability test samples were prepared and heated to different temperatures by a method that had been thought out beforehand with a view to preventing the breakdown of the cylinders. The permeabilities were then measured in the cold state, as it must be remembered that the constitution at high temperature must be maintained on cooling. In practice, there is merely a difference in the volume of the gases to be removed, this volume being a function of the temperature, and although it was impossible to do this, the difference in question could be calculated and taken account of, and this would, of course, still further accentuate the alterations found. The figures found are plotted in Fig. 1, which exhibits a very appreciable diminution in permeability at a certain moment, and, reaching a minimum towards 1,150 deg. C., afterwards increases. With a view to linking up these results with the behaviour of the bond, the sand was investigated separately after washing. This investigation showed that the part AB of the curve gives the attrition (grésage) of the bond, this phenomenon being accompanied by considerable expansion of the material, terminating in its melting and gradual contraction from about 1,160 deg. C.

It may be mentioned, incidentally, that this action of the bond on the properties of sand at high temperatures does not only depend upon its nature and refractory properties, but also apparently to a considerable extent on its distribution and adherence to the surface of the grains. What is termed the "fixed bond" apparently plays an important part in this connection.

For a given product, at all events, the higher the properties in the cold state, *i.e.*, the more perfect the distribution of the elements, the better the properties at high temperature.

This is perfectly logical if it is borne in mind that the action of the bond is always expressed

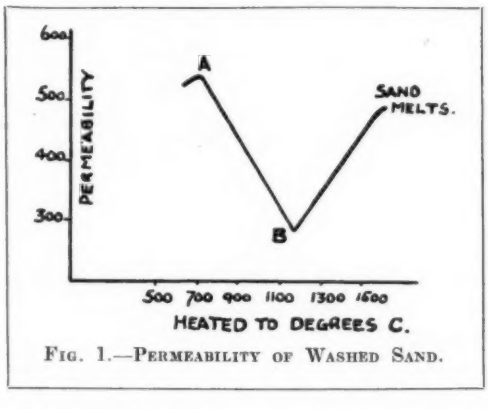


FIG. 1.—PERMEABILITY OF WASHED SAND.

by the same diminution in the properties in whatever way it may be distributed. In the light of initial experiments made in this matter this hypothesis seems superfluous, the better the bond is distributed around the grains, the less its tendency to act separately at high temperature to produce the deleterious effects mentioned.

Preparation.

Assuming the existence of old and fresh sand, the preparation of the mixtures consists in distributing as uniformly as possible around the grains the bond and the small particles that adversely affect permeability and which cannot be eliminated. This operation is generally followed by a separation of the grains that have been covered in this way, this action being produced by means of the disintegrator.

It is well known that by properly preparing a mixture, its permeability and cohesion when cold, and also when hot, are augmented. The proper control is just as important, therefore, as the composition, and it may easily be carried out by means of apparatus for measuring these properties. In a given foundry the machines available in the sand shop are generally pretty much the same, and attention should therefore be directed particularly to the method of preparation.

In practice there are two processes for getting the distribution of the bond and the sand grains: the first consists in thoroughly mixing the old sand and the new in the dry state, and then wetting the mixture; the other consists in wetting the mixture first and then subjecting it to mulling in order to get the desired distribution.

The first advantage of permeability and cohesion tests is to show that, in the majority of cases, the second of the two above methods is preferable to the first for natural sands. The

* "Commercial Application of Moulding Sand Testing." Trans. A.F.A., Vol. xxxii, Part II.

reasons for this are pretty simple, but the following are a few of them:—

(1) Except in special cases, it is undesirable to crush the grains, because, as mills are generally used, this fragmentation is considerable when working in the dry.

(2) If it be desired to distribute the bond in the form of a layer around the grains, then the bond must be plastic, *i.e.*, moist, because if dry, merely mixing and not distribution is effected.

(3) The plasticity of a bond, which is a clayey material, depends, apart from its own nature, on the amount of water it may absorb colloidally. It is better therefore to leave its natural water, because it is impossible to say ever whether it may reabsorb it after drying.

(4) It is a common notion that kneading a moist clay increases its plasticity—another reason for working the sand with water.

There are, however, raw materials which are difficult to incorporate in used sands without previous drying. Such products are those in which the bond is naturally very badly distributed and forms nodules of clay distributed over the mass. These nodules become covered with all the dry powder of the old sand, assume the consistency of rubber, and are no longer able to cover the grains, whereas, if previously dried, they disintegrate.

It is sometimes possible with these materials to obtain good results by proceeding as follows: Pure new sand is mulled by adding the necessary water for moistening the mixture. The nodules become very plastic and are distributed around the grains. The old sand may then be added. In other cases it is of advantage to mull the fresh sand simply with the natural water it contains in it, and to add to it afterwards the old sand suitably moistened.

The Addition of Clay to Sand Mixtures.

A certain percentage of clay is sometimes added to a mixture to increase, say, its cohesion. The results differ greatly according to whether this clay is added in the powdered form or in the form of a thin paste prepared in advance with the aid of the water that must be incorporated in the mixture. In the course of an experiment carried out by the author, the additional quantity of clay necessary to obtain the same cohesion was cut down by half by means of the second process, with considerable benefit to the permeability.

These examples have been mentioned to show the importance of moisture in all these questions; for it must be remembered that this factor plays an outstanding part through the plasticity of the bond.

If the work of a muller be carefully studied, and curves be plotted showing the variation of the properties of sand in terms of time of muller, it will generally be found that: (1) Permeability begins to diminish more or less appreciably, afterwards increasing and reaching a value that is practically constant after a certain time, this latter being variable, and (2) cohesion also tends towards a kind of limit.

The initial diminution in permeability is due to the fragmentation of the grains at a time when they are not sufficiently protected by the bond. This protection is really good distribution of the bond, or, put another way, the maximum good properties are more quickly reached when, other things being equal, the plasticity is very high.

As time is an important matter in the sand preparing shop, it is sometimes regarded an advantage to carry out the mulling operation with an excess of moisture, allowing the mixture to dry slightly before using it. *En passant*, it is desirable to examine in this connection sands which, in the crude state, exhibit maximum permeability, and, more specially, cohesion, for high percentages of water.

In this respect the following experiment may be mentioned: Three parts of the same mixture were worked up in exactly the same way, but with different percentages of water, viz., 5, 7 and 9 per cent. The percentage moisture was then standardised at 7 per cent. (the sand with 5 per cent. moisture having been wetted by 2 per cent. and the sand with 9 per cent. moisture dried in air for a sufficient length of time). The permeability and cohesion after this operation were not the same. For the portion of sand mulled with 9 per cent. water these properties were higher than the others by 15 and 20 per cent.

This case is probably not general, but it shows the importance of studying these questions where the products actually available have to be used.

From the standpoint of the preceding remarks an attempt might be made to draw up a programme for the preparation of a definite mixture with a view to obtaining the highest possible properties in a time compatible with the necessities of production.

Assuming, for instance, a sand mill with constant characteristics (weight of runners, width of runners, speed of rotation of the pan), then three related factors should be investigated: (1) Thickness of sand placed in the pan; (2) time of mulling; (3) moisture. The thickness of sand plays an important part relatively to the crushing of the grains and the extent and intensity of mulling.

The time of mulling is related to the percentage of moisture in view of the properties to be obtained, and governs with the thickness of sand the production of the apparatus. Moisture, of course, plays the part already mentioned.

It is convenient to determine first of all, according to practical requirements, the time of mulling and the moisture; information on this latter point being obtained, as already stated, by curves showing the variation in the properties of sand in the raw state. The effect of the thickness of sand is then investigated by permeability and cohesion measurements. When the two other factors have been determined, the time of mulling and, finally, the moisture, should be studied.

Sufficiently accurate information will then be available in order to determine the conditions under which the operations are carried out. It is not meant to imply that the investigation should be systematic, because this would mean varying highly complex and closely related factors; but the rough-and-ready method suggested may be extremely useful in the process of sand control.

A great advantage of this method is that it gives information as to the effects of daily variations in the percentage of water in the mixtures, and enables the limits of such variations to be fixed. Certain products are more sensitive than others to these fluctuations, and so require greater care and attention. Since these experiments are not made in the laboratory, but in the sand preparing shop it is necessary to be able to determine the moisture, as well as the other properties, very rapidly and, if necessary, at some expense of accuracy.

An apparatus of the kind suggested by H. Dietert* is very satisfactory in this connection. It may be formed of a tube (A) (Fig. 2) closed at the top by a plug (B) containing an electric heating wire and containing inside a compressed air pipe. The bottom of the tube (A) contains a small sieve (D) supported on legs. The electrical part of the device comprises a rheostat and an ammeter.

After having inserted the sieve (D) containing, say, 10 grams of sand, the current and flow of air are adjusted so that the temperature on the sand is 200 deg. C. Perfect drying is therefore effected in a few seconds. The loss of weight gives the quantity of water contained in the sand under investigation, this quantity being expressed as a percentage of dry sand by means of a chart prepared in advance. To accelerate operations it may be possible to add a weighing device which would directly indicate this percentage.

Obviously, once the adjustment has been made, it is not necessary to do it over again for each determination. It will be seen that the sieve has been adapted so as to give very quick drying. A small disc (D) collects the portions of sand that may have been forced through the sieve by the compressed air. Once an apparatus of this kind is hot, it enables a humidity determination to be made in three minutes, and only five minutes are required for heating up.

II.—Controlling Raw Materials.

With a view to obtaining the continuity of results that is desirable in manufacture, new

* H. Dietert. "Commercial Application of Moulding Sand Testing." Transactions, A.F.A., Vol. xxxii, Part II.

sands reaching the foundry must be checked with a view to recording any variations they may exhibit before an increase in wasters calls attention to them.

This control is difficult to organise, and among all the methods of investigation that have been examined, the foundryman must ascertain which of these should be adopted in his case. The strata in sand-pits are rarely uniform and homogeneous, but one might assume that, apart from a few differences in chemical analysis and mechanical properties, the products obtained when of the same geological origin must be practically constant as regards their intimate constitution.

This is not always the case, however, and although the question has not yet been investigated to any great extent, differences have been found. The following example may be quoted.

A new sand used in a steel foundry and 50 per cent. of which was used along with old sand to form the mixture, was giving satisfactory results, when, a further consignment having been delivered, the percentage of waster castings began to rise rapidly. The mechanical and chemical analyses carried out on the fresh product did not reveal any appreciable difference compared with the sand previously used, but an investigation of the variations in permeability in terms of moisture showed a marked difference. The curves obtained are shown in Fig. 3. They take the same form, but exhibit a deviation from the horizontal corresponding to about 2 per cent. of moisture. The percentage of water used in preparing the sand and moulding is 7 per cent., so that, in view of the slope of the curves, the difference in permeability is considerable.

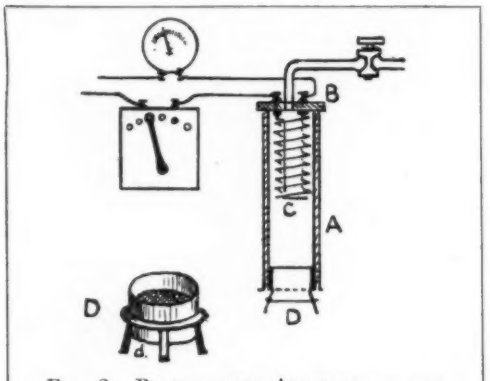


FIG. 2.—PERMEABILITY APPARATUS OF THE DIETERT TYPE.

The control of the preparation was resumed according to the broad outlines given above, with a result that the dotted line was displaced and sufficient permeability obtained. The percentage of wasters then decreased rapidly. The cause of the difference in behaviour of the two products was never known, but it is none the less true that the knowledge of this difference, had it been gained before using this fresh sand for moulding, would have prevented the rejection of a number of castings.

This is a fairly typical example, and shows what may be done by careful investigation with a view to controlling these methods, which have been mentioned as a supplement to the ordinary analysis to ensure practical comparability of two natural sands.

Among the methods that may be used, a choice must obviously be made, because it would take too long to apply all of them, and, moreover, they are all related to each other, and in the case quoted it is highly probable that the curves showing the variation of cohesion would have revealed the same kind of difference.

It is very difficult to give in this Paper precise rules, because it only deals with the subject in a general way; but it is certain that, where the arrangements at the quarries enable a definite check to be made of the uniformity of their products, it will be useless and ineffectual to make chemical analyses on material from each consignment; it will be preferable to rely upon the help of apparatus for measuring permeability and cohesion rather than on special measurements of the kind that have been discussed.

III.—Controlling Prepared Sand.

The thing here is to know at what moment these control operations should be exercised. If one examines what takes place when mixtures are utilised it will be found that, for moulding operations, a material is used which comes from the sand preparing plant. It is rammed by some means or other, and the decrease in volume which it undergoes, assuming the force applied and the product to be the same, depends upon the moisture in the sand at that moment. When casting in green sand the surface layer dries more or less during the time which elapses between the making of the mould and the arrival of the metal. If the mould is stoved, it dries completely, and is even baked sometimes. Finally, during casting, the qualities of the mixture undergo unknown variations. In the whole of this cycle the permeability and cohesion undergo changes, but their successive values are correlative and interconnected.

The methods of preparation govern the values A of the properties of the mixture. The moisture at the moment of moulding governs the ramming and leads to other values B. The subsequent treatments to which the moulds are subjected give fresh values C for the properties, which finally assume still further values D during the operation of casting. Obviously it is these last values that have the greatest influence on the results, but they cannot be measured, especially for control purposes. The values that it is most important and convenient to control are the values B, and they must be kept in mind in any daily investigation. Their measure forms a kind of specification test of the products supplied by the sand department of the foundry. Once these methods are properly defined and controlled, an apparatus for determining moisture will be a sufficient guide in its work.

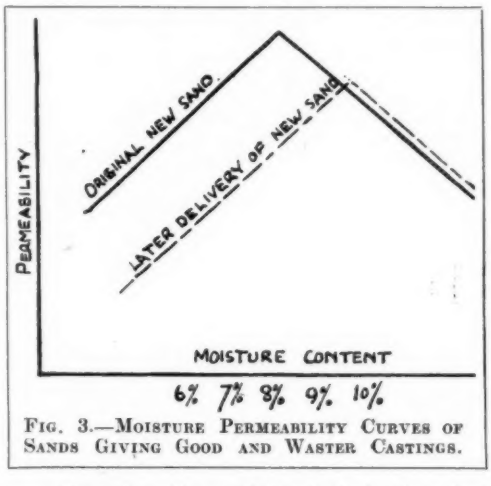


FIG. 3.—MOISTURE PERMEABILITY CURVES OF SANDS GIVING GOOD AND WASTER CASTINGS.

As regards this evolution of permeability and cohesion, it may be mentioned that the values C corresponding to stoved mixtures often do not differ greatly from the values B, at least in respect of the first of these properties. But this does not prove that stoving is useless, but shows that it simply acts by greatly decreasing the quantity of gas that has to be liberated, because it takes a great deal of the water from the sand.

Conclusion.

The author has attempted to show that apparatus for measuring permeability and cohesion in the cold state, when employed according to certain methods, may be of great service in the foundry. They enable the best way of utilising the products to be determined, and the uniformity of such products to be controlled day by day with a view to obtaining uniformity of results in manufacture.

Except as regards the question dealt with in the last paragraph, in the light of what has been said isolated measurements of the properties of sands should not be undertaken, as very often they signify nothing, whereas curves of variation plotted according to a fixed method and with a definite purpose in view are generally productive.

Non-Ferrous Metallography.*

By J. S. Glen Primrose, A.R.T.C., A.I M.M. (Assoc. Member), Manchester.

INTRODUCTION.

Since the writer drew attention to the importance of "Metallography as an Aid to the Ironfounder" at the British Foundrymen's Association's Glasgow convention in 1911, there has been an increasing use of the microscope as an adjunct to foundry work, and the wide scope afforded by its application to control and investigation work in the non-ferrous field has been dealt with by noted writers in the Institute's proceedings.

There are so many aspects of the case—whether pure research into new properties, pathological investigation of failures, or examination to ensure compliance with rigid specifications—that it is not possible in limited space to deal fully with all of these; and the present object is to draw attention to the results of some slight practical experience in all of these fields, which may prove of value to practical workers endeavouring to establish standards of comparison to follow or avoid. The general tendency lies in the direction of illustrating only ideal structures and those representing exceptional conditions or strengths, whereas it is often more valuable to be able to recognise the appearance of defective structures in order to assign the proper cause to them, and thus know the direction to go in order to avoid a repetition of the trouble. Another common failing is to resort too soon and too frequently to excessively high powers of magnification for the particular structure under examination, and thus the general appearance of the structure is apt to be overlooked. Wherever possible, a three-fold record should be taken showing first the simply polished surface to indicate size and distributions of inclusion or blow-holes at low powers, then the same spot suitably etched, and finally a definite central area at a higher magnification to reveal the minute arrangement not seen at low power.

Apparatus.

A review of the micrographic outfits available for various classes of workers during the last two decades clearly shows the reasons for the great

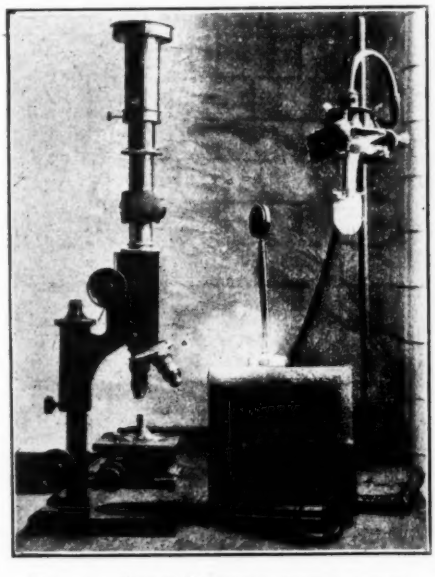


FIG. 1.—REJTÖ VERTICAL STAND, WITH GORDON MICRO CAMERA.

advances made in the technique of practical metallography. For purely visual work, the simple vertical mounting of the microscope tube has been greatly simplified from the original model resembling the petrological stand, and to-day there are several exponents of the compact tripod mounting due to the late Dr. Stead.

Perhaps the earliest attempt at making the purely laboratory instrument available for the workshop also was the Rejtö stand[1] shown in Fig. 1. In this the wide body tube carried the eye-piece in an elongated form of vertical illuminator, placed in this case near the top of the mounting. The lower end of the microscope tube carried two or three objectives in a revolving nose-piece, which greatly facilitated the transfer from one power to another whilst retaining the same spot of the specimen for inspection. Between the horse-shoe base and the pillar carrying the fine adjustment screw of high accuracy, which even with prolonged wear developed no appreciable back-lash, there was fitted a removable object-stage with a long-reach rack and pinion motion for accommodating a wide range of specimen sizes. This mechanical stage could not only be levelled accurately by means of two screws and a fixed-length third leg, but could also be made to traverse horizontally in two directions rigorously

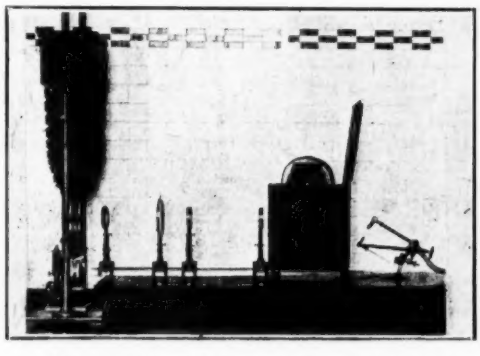


FIG. 2.—REJTÖ MICROSCOPE, VITH ARC LAMP AND OPTICAL BENCH.

at right angles by two fine screw spindles mounted co-axially, which was of considerable service in operation by touch instead of after visual finding. Two set screws at the base of the pillars enable this intermediate section carrying the stage to be readily removed, leaving the microscope available for direct setting upon any large object in place, without the need of removing a section to be examined. The illustration shows the inverted gas-mantle source of light and the small Gordon photo-micro camera over the eye-piece. This small attachment was sufficiently portable to enable it to be loaded with a plate in the dark room, and it was placed over the microscope and the exposure made by a small slotted disc above the lens. A focussing magnifier the same length as the camera enabled very clear images to be obtained in a very simple fashion. For more elaborate work, the use of an electric-arc source of light was deemed advisable, and for varying magnifications the various condenser combinations of the optical bench was a great help when accompanied by a large aperture iris diaphragm. This arrangement is shown in Fig. 2, in which case the photographic attachment consists of a vertical bellows camera sliding upon two fixed uprights after the Nachet principle. The upper box portion, with the plate carrier grooves, could be clamped in any desired position, but the lower connection was a simple light-tight one resting on a ring concentrically covering the microscope eyepiece.

The inconvenience of either having to place the microscope very low down to have the camera top at a convenient height, or else having to mount an elevated position to focus the image on the screen if the microscope was placed at a convenient working level, was overcome by another arrangement, and this consisted of having the microscope tube capable of pivotting backwards through a right angle, whilst still resting upon its base, and thus the camera attachment could be connected horizontally after the visual examination had been performed with the microscope tube in either a

* A Paper read before the Annual Conference of Institute of British Foundrymen.

vertical or in a suitably-inclined position. This still necessitated the very careful mounting of the micro-specimen, and if no levelling device was attached to the stage, then some form of stepped base-plate or the sliding tube device of Stead was a great boon to workers who required to get through a number of examinations in a limited time.

The greatest advance came with the idea of the inverted stand[2] introduced by Le Chatelier, in which the objective pointed upwards, and the customary difficulty of levelling the specimen was overcome by the simple expedient of placing it, polished face downwards, upon a little circular tripod stand, the legs of which rested in a grooved ring capable of rotation for final focussing, and

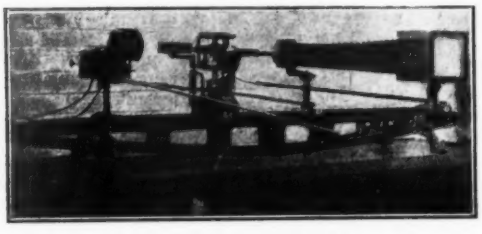


FIG. 3.—REICHERT INVERTED MICROSCOPE, WITH OPTICAL SYSTEM ATTACHED.

the length of the legs was selected to suit the varying focal length of the objective. This improvement by Dujardin over the original Pellin method of adjusting the focus by means of screwing a tube with the necessary perforation in the base, up and down on the sub-stage continuation of the body tube, was a great advantage in changing objectives to secure different magnifications.

Many modifications of this Le Chatelier design have been elaborated and put upon the market, such as the overhanging arm type, which soon gave place to the four-column arrangement of Guertler, and finally the most substantial form now embodied

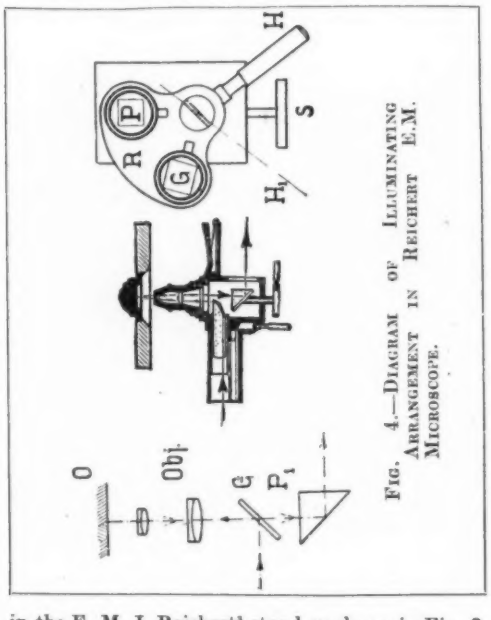


FIG. 4.—DIAGRAM OF ILLUMINATING ARRANGEMENT IN REICHERT E.M. MICROSCOPE.

in the E. M. I. Reichert[3] stand as shown in Fig. 3. A very full description of this has already been published, but passing reference should be made to the ease in manipulation where large numbers of specimens have to be examined and also photographed with the minimum of trouble and time expended upon them. Thus five photo-micrographs of the same spot, both unetched and etched, can readily be made within a period of five minutes. One of the most important features is that the position of the mechanical stage and also the illuminating prism can be set for the correct focus of any objective without the presence of any specimen, suitable graduations being provided to enable this preliminary setting to be made without reference to the image of the object. Another great facility in rapid manipulation is the ease with which the prism can be withdrawn into its carrier tube, the arm swung over into a second definite position, and a suitably inclined cover glass brought into position for the reflected type of illumination instead of the transmitted form when the prism is used. The mechanism of this arrangement is worth illustrating in the three accompanying sketches, Fig. 4, which shows the path of the light rays, and how readily the change can be effected, without disturbing the microscope or specimen in any way. The Prism P_1 can be

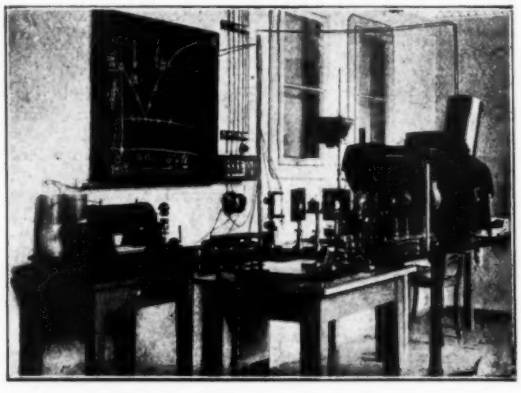


FIG. 5.—MARTENS' HORIZONTAL STAND, WITH ULTRA-VIOLET LIGHT ILLUMINATION.

rotated through a right angle, thereby allowing of either direct visual observation of the object, or the projection of the image for photographing into the camera below. The objectives are provided with a simple bayonet catch, whereby they can be changed in the minimum of time, since they carry no screw to fasten them. The author has found that exceedingly high-class work can be done with this instrument, which represents the greatest possible saving of time in both visual examination and in taking photographic records for comparison.

Illumination.

Just as great advances have been made in regard to improved sources of illumination, as have been

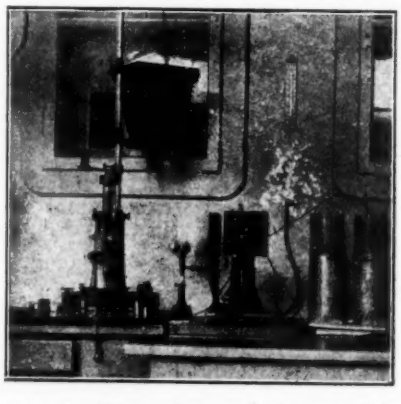
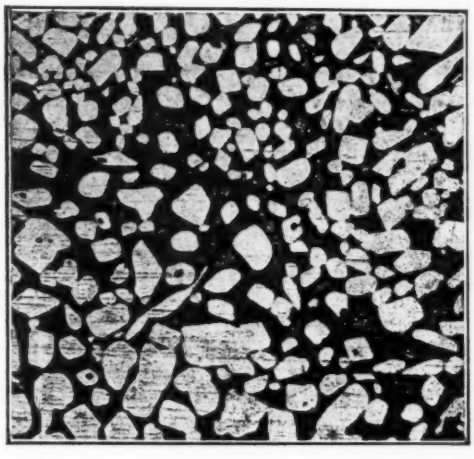


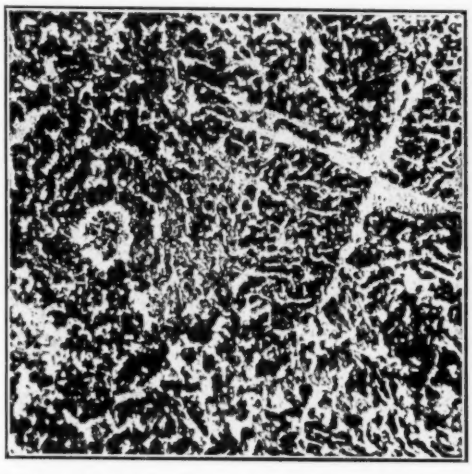
FIG. 6.—ZEISS VERTICAL CAMERA, USED FOR ULTRA-VIOLET LIGHT RESEARCH WORK.

effected in metallurgical microscope construction. The ordinary microscopist's oil lamp was early replaced by some form of incandescent gas mantle, the inverted type offering certain advantages. The incandescent electric lamp was less satisfactory, especially as it has to be used in a frosted glass bulb to prevent the filament image being projected on to the screen, and the simplest expedient of directing a small oxygen-coal-gas blow-pipe flame on to the upturned end of a porcelain mantle-stem was one for long in use in the laboratory of Doctors Martens and Heyn at Lichterfelde. The Nernst lamp had a short vogue, but was soon superseded by the more suitable Pointolite, which gives excellent results for most purposes of observation, and is also available for photographic work. The author's preference has

always been in the direction of an arc lamp, and several types of automatic-feed carbon arc have proved satisfactory, these usually being of the inclined electrode form. The neatest and now almost universal form is the small carbon right-angle arc, which usually does not take more than 5 or 6 amperes to incandesce.

In the E.M.1 type of microscope stand above referred to, it is of considerable advantage to have the light-condensing system all mounted on a small attachment to the miscroscope stand, and

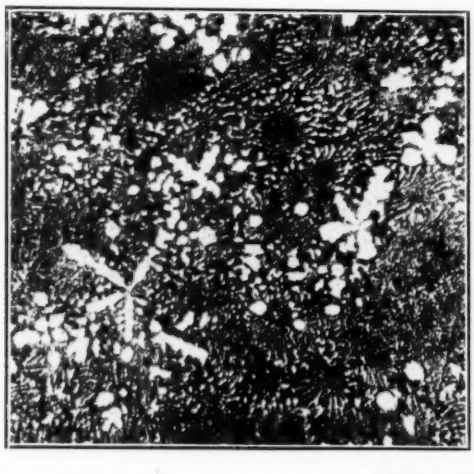




FIGS. 7 AND 8.—V—50—X.

to obtain concentricity of the beam of light from the arc, flexible connections to two quadrant adjustments enable the arc to be brought easily into the best position.

When using arc-lamp illumination, the great tendency is to overexpose the photographic plate, even when such slow speeds as H. and D. 45, if the fine-grain ordinary variety is used, and a screen is employed partly to counteract this, but also to sharpen the image by elimination of the



FIGS. 9 AND 10.—V—50—X.

various light wavelengths which are not correctly registered by achromatic objectives and huyghenian eyepieces. One of the most generally useful is the K.10 yellow screen, which can be secured either in glass or as a gelatine film, but for other purposes the green filter is frequently used. The disadvantage of liquid filters is that they are difficult to keep clear of bubbles, and even the cooling trough presents the same feature unless potassium-alum is dissolved in it to form a concentrated solution. Special light filters are required when panchromatic plates are used, and also in the case of recording the various shades of colour produced on polished specimens by suitable heat-tinting or oxidation etching, by the aid of the auto-chromatic plates successfully introduced by Lumière.

When particularly high-resolving power is required from a microscope lens-system, it is found that this advances in direct proportion to any decrease in the wavelength of the light used. Thus for very high powers, when research is being undertaken into the inner structures of eutectics, or of microscopical constituents the exact shape of which is not revealed by ordinary white light, it is possible to make use of ultra-violet light. By utilising the special objectives known as "monochromats," designed from the formulæ of Dr. M. von Rohr, which are corrected for ultra-violet light having a wavelength of 275$\mu\mu$, the resolving power is double that of a similar numerical-aperture ordinary lens. These lenses are made of quartz which has not been fused, as this destroys their refractive index, but simply rendered plastic by heating in an oxy-hydrogen flame, and then moulded to the approximate shape required. The polishing to the correct shape requires special care, and they can, of course, only be used with this light, being quite useless for light of different wavelength, particularly daylight. The 6-mm. objective is used dry, but the two higher powers available for magnifications between 3,000 and 5,000 diameters, and having numerical apertures of 0.85 and 1.25 respectively, are immersion systems, in which the fluid used is a mixture of pure glycerine and distilled water in the proportions calculated to give a definite refractive index.

The eyepieces, for projecting the image on to the photographic plate, are also made of quartz, and similarly the necessary condensers in the illuminating apparatus are made of the same

material. So, too, are the two right-angle prisms used on the optical bench for reflecting the light emitted by a nearly continuous series of sparks, produced by the Leyden jar and large induction coil, between the points of the cadmium electrodes. The photographic apparatus recommended for use with this outfit is the vertical form of camera attached to a steel upright which can be swung about its bottom pivot, and thus alternately bring into position over the microscope eyepiece, first the searcher, consisting of a fluorescent screen of uranium glass to render the otherwise invisible

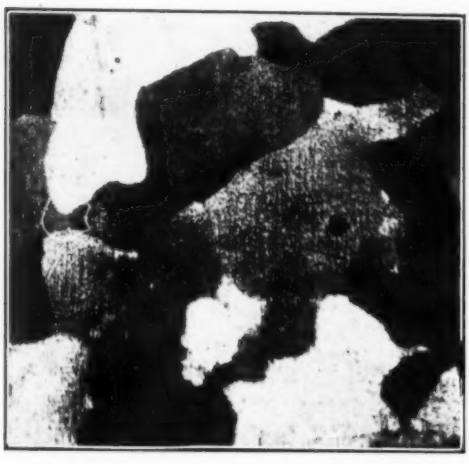


FIG. 11.—ALPHA BRASS—SPECIFICATION A (V—50—X).

image capable of being focussed by a powerful magnifier, and secondly, the camera itself, which, if approximately 30 cms. extended, permits the exposure to be made without further inspection.

In working with this arrangement whilst conducting some research work for Prof. K. Friedrich at Freiberg Bergakademie in 1907, the writer overcame the inconvenience of the vertical camera arrangement, which at high powers did not record a sharp image even after the searcher had done so, and therefore a final focussing was needed on the

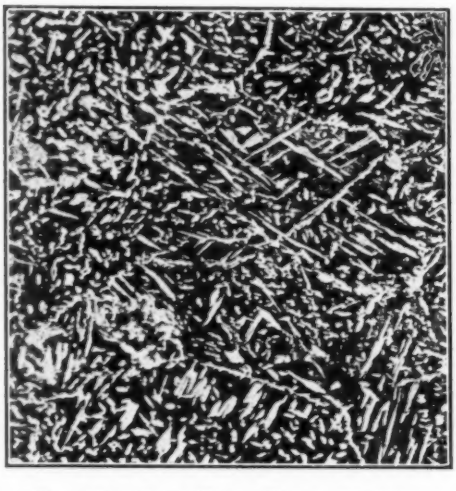


FIG. 12.—ALPHA-BETA BRASS—SPECIFICATION B (V—50—X).

full-sized fluorescent screen. To do this the Martens' horizontal stand was selected, and after the desired spot had been photographed by ordinary white light emanating from the right-hand side, the sliding objective changer and prism were exchanged for the quartz set, and the same spot was examined and photographed by the pencil of ultra-violet light coming from the special illuminating table placed on the left-hand side, as shown in Fig. 5, Fig. 6 showing the original arrangement used. The structures examined were chiefly of non-ferrous alloys from the famous series of arsenides and sulphides investigated by Friedrich, and in several cases structures and shapes not previously revealed were made clear by the aid of the ultra-violet light photo-micrographs[4], some of which have already appeared in "Metallurgie," Vol. V., Heft 20, of Oct. 22, 1908, p. 593. That the microscope fitted with ultra-violet light apparatus is an instrument of greater precision and power than any other available for micro-metallography is only now being appreciated in some quarters.*

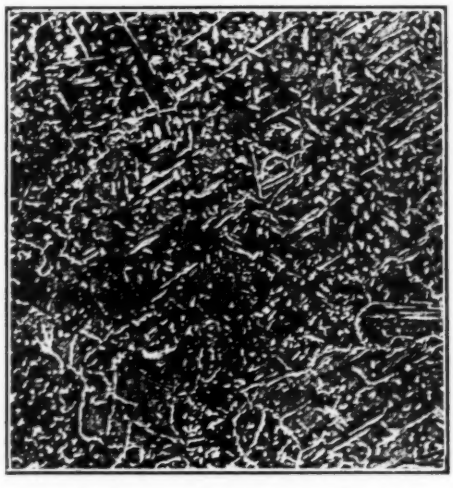


FIG. 13.—ALPHA-BETA BRASS—SPECIFICATION C (V—50—X).

Microstructures.—In the scope of non-ferrous metallography there is a very great variety of known types of structure, and an even richer vista opens before the practical worker in this field than in the general run of the ferrous metal-structures. To the research student there is an even greater possibility of variations, and the careful development of these by suitable polishing means and selective etching reagents is a very interesting and instructive range of work. Numerous lists have appeared from time to time of special agents of limited application, but it is surprising what

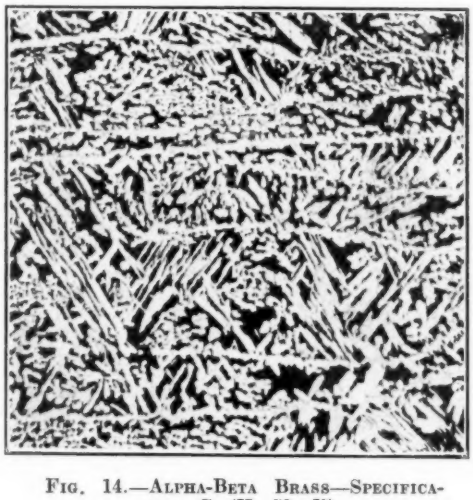


FIG. 14.—ALPHA-BETA BRASS—SPECIFICATION G (V—50—X).

generally useful application can be made of the old ferric chloride solution in the majority of practical working cases.

(To be continued.)

A Binder for Cement to Withstand Heat.—A reliable binder for cement which has to withstand very high temperatures is sodium silicate (commonly known as water-glass), diluted with rain-water until a 20 degrees specific gravity (Baumé hydrometer quoted) is reached. To give the cement its proper consistency, sand should be added.

Some Notes on the Production of Cylinder Pig-Iron to Fracture and Analysis. *

By E. J. Yates, B.Sc.(Met.).

The object of this Paper is to outline some of the difficulties and experiences on the production of cylinder pig-iron from the metallurgical and technical points of view. The task may be defined as an undertaking "to produce a cylinder iron of constant dense grey and close fracture to the following characteristic analysis: Total carbon under 3.2 per cent. and the silicon varying between 1.2 and 3.0 per cent.

The writer's experience has been at the Goldendale furnaces. These furnaces are peculiarly suited for this work, the output being small and the driving very slow, with a low-blast temperature; obviously the cost of making is far higher than with modern furnace practice based on large outputs.

Undoubtedly both the fracture and analysis are necessary for a complete definition of an iron, coupled with a very important proviso, *i.e.*, the type of furnace used. The iron produced in a small, slowly-driven furnace is of very different type from that produced from a large and more rapidly driven one.

These factors of furnace design, blast temperature and slow driving at the Goldendale furnaces are responsible for the low total-carbon iron produced, which is definitely suited to cylinder-casting manufacture.

Most careful attention is given to details of furnace working, both as regards quality of product and also the percentage produced. These factors are to be borne in mind during the subsequent part of this Paper.

There is on view at the Exhibition a dual series of fractures of this pig-iron. One series shows how the fracture can vary progressively from open iron to white iron, the silicon content of the series falling between 2.26 and 2.06 per cent., for all intents and purposes a uniform figure. The other series shows how the cylinder fractures are indistinguishable, with the silicon varying progressively from 1.4 to 4.6 per cent. It must be emphasised that these pigs have been normally cooled in the pig beds, the cooling conditions changing only with the seasonal variations.

These specimens show how the fracture and the most important element of the analysis, which is usually regarded as the controlling criterion of fracture, are not necessarily related at all.

It is usually taken for granted that the more open the grain the higher the silicon, and up to a point that is true; but by varying the operating conditions of the furnace, however, the whole range of silicon contents may be altered. So one gets the apparent anomaly of an open-grain iron containing 2 per cent. silicon and a close-grain cylinder iron with 4.6 per cent.

It is as well to digress for a moment. These terms "open" and "close" are difficult to define. The usual way is by numbers—No. 1, No. 3, etc., but this is a purely arbitrary one, and it is generally found that the grading of pig-iron is in the hands of the senior piglifter. This is not as it should be. The size of the graphite flakes varies over the face of a pig in a No. 3 iron, for instance, and together with the relative amounts determine the class into which the iron is to be placed. These fracture numbers from different plants bear a general analogy, but the only way would be to measure the average size of the graphite plates.

The phosphorus-content of the iron is entirely dependent on the amount present in the furnace burden, and all the phosphorus goes into the metal. Consequently, it is a serious matter to alter the phosphorus, necessitating a radical alteration in the burden, with consequent changing of supplies of raw material.

The manganese content is dependent on the furnace. Of all the elements, this is the least under control in cylinder iron. A partial reduction only takes place, and whilst the proportion of the manganese thrown into the iron remains tolerably constant for open irons, it dwindles rapidly as the furnace changes "colder," and a much smaller proportion passes into the iron when the furnace is comparatively cold and producing white iron. Cylinder irons are on the border line between white and open irons, and this results in a very variable amount being reduced.

Sulphur is always the *bête-noir* of the blast furnace, and it is advisable to carry a fair proportion of manganese to keep this within bounds—particularly when using coke high in sulphur (1.3 per cent.).

But there is another point of view. A high-manganese pig is desirable in the foundry. There it again helps to cure the equally important and pernicious problem of sulphur in the cupola. The sulphur in ordinary small proportions exists in high-manganese iron as manganese sulphide, which is innocuous compared with the iron sulphide in low-manganese irons. The manganese sulphide shows a tendency to slag off in the cupola, and a fair proportion of manganese in the cupola charge is an almost automatic antidote to sulphur. Manganese has no deleterious effect when present in amounts insufficient to cause brittleness, say under 2 per cent. to be on the safe side.

It must be understood that whilst a great measure of control is exercised in a blast furnace by very careful attention to the many variable factors, the only way finally to grade is by analysis.

Thus there is the twin specification of fracture and analysis as a complete description. Both are of great importance, but neither is complete in itself.

The fracture is a guide to the internal structure of the metal, which is, after all, the main consideration in the finished casting. Remelting an iron does not destroy its original structure, though it may be modified due to varying cooling rates, but as ordinarily cast, the structure obtained is the same as in the original pig.

The fracture shows the macro-structure of the pig, and this is a physical test which, roughly speaking, gives a clue to the micro-structure. The size of the graphite flakes bears a very close relationship to both the total carbon and the combined carbon, irrespective of the other constituents. These two, perhaps, form the most important factors in the properties of the finished material

It will be seen that up to a point the fracture is an adequate guide. It shows the main properties of the material. The chemical analysis alone is no guide to the fracture. Given any particular analysis, it would take a very bold man to state the fracture. The fracture shows immediately the size of the graphite plates which have such an important effect on the physical properties, but the chemical analysis gives no clue whatever to this.

How can analysis reconcile the difference between two similar fractures of close cylinder iron from two different plants, one with 3.2 per cent. total carbon and the other with 2.9 per cent.? This is bound up in the question of manufacture, and each blast-furnace plant, under its own individual conditions, despite the similarity of ores used, etc., produces a distinctly different product.

Yet, as has been seen, the fracture gives no real clue to the micro-structure. The fundamental difference between 1.4 and 4.6 per cent. is enormous, and yet the two fractures on view are indistinguishable. The "fracture diviner" is here at an utter loss, as is likewise the chemical analysis by itself. Whence lies the difference? It is solely in the differing operation of the blast furnace itself.

The analysis gives the final key to this structure. The analysis, *per se*, is useless; it must be trans-

* A Paper read before the Annual Conference of Institute of British Foundrymen.

lated into the terms of the structural analysis. From the foundryman's point of view the analysis is important, but it is only of real service if he knows the analysis of the scrap used and the required analysis of the finished casting.

The structure of a cylinder iron produced in a slowly-driven furnace is much more uniform, and a more even and regular distribution of the micro-constituents is found. The distribution of the micro-constituents, apart altogether from their incidence, plays a very vital part in the physical properties of the finished casting. In practice, for some inexplicable reason, such iron mixes more readily and easily with the other proportions of the cupola charge, and produces a stronger iron.

The vital factors in the fixing of a specification are—the type of iron desired and the limits to which the manufacturer can reasonably keep in supplying the iron consistently.

A close specification is possible for small amounts of material for special work, but where consistent supplies are demanded, it proves very awkward to get such supplies consistently. The terms of a specification should not be too rigidly fixed. On one occasion it may be possible to meet it, but on another no material may be available.

What are the possible permutation and combinations amongst fracture, total carbon, combined carbon, silicon, manganese, and phosphorus? Pig-iron is not like steel, where the operation is under excellent control. Each one cannot be strictly specified to small limits.

The silicon limits usually worked to are with a 0.5 per cent. allowance, say from 1.5 to 2.0 per cent.; 2.0 to 2.5 per cent.; 2.5 to 3.0 per cent., and so on. It is only in very special work that any closer limits are any use to the foundryman. His own scrap must indeed be above any suspicion if a closer specification is to be of any benefit at all.

An important factor in the supplying of pig-iron to analysis is the sampling. Special steps are taken at the Goldendale furnaces to ensure the greatest possible homogeneity throughout each cast, but it must be remembered that the pig-iron from a blast furnace is liable to slight variations in composition. Three pigs are sampled for drilling—one from the commencement of the cast, one from the middle, and one from the end, and the average of these is the average analysis of the cast.

Some standard method of drilling the sample pigs is desirable. Slight variations occur over the surface of the pig, particularly with regard to the combined carbon and the sulphur. A fair way is to drill the pigs through from bottom to top, omitting, of course, the skin by a previous skimming and rejection of the drillings. The skin of a pig is invariably high in sulphur, and if included is liable to upset the estimation of sulphur and silicon.

With regard to the variations in analysis obtained between one chemist's determination and another's, these can, in the majority of instances, be traced to variations in the method of sampling. On a given sample the results do not, as a rule, vary appreciably. Varying methods of analysis do occasionally cause dissension. Standard methods of drilling for sampling and analysis are urgently required, and a very useful purpose would be fulfilled if these could be settled. One of the technical bodies now existing could serve a very definitely useful purpose by so doing.

When ordering pig-iron, it saves much trouble if the question of the specification is thrashed out beforehand. In the first place, an open discussion as to requirements will clear the air and the definite requirements of the foundry formulated.

Different foundries attach quite special importance to portions of the specification, which others almost ignore. If such points are cleared up it saves expense. For instance, it is quite absurd to specify combined carbon which cannot fit in with the fracture desired. Yet such occurrences do happen. A frank discussion with the supplier always repays itself, particularly with regard to the fracture desired.

The suppliers are always open to giving the correct material desired, and are anxious to avoid that almost, in practice, water-tight divisions between the blast furnace and the foundry. No specification is universal, and it is apparently, as yet, hopeless to fix one. Requirements differ very much.

In conclusion, it is hoped that these few notes have given you some idea of the complexities confronting those engaged in the supply of pig-iron to specification of fracture and analysis, and the writer would plead for a greater co-operation between supplier and user in the many problems and details which arise.

Heat Treatment of Chains.

In the annual report of the National Physical Laboratory, recently issued, reference is made to work which is being carried out in connection with the heat treatment of chains, which is a practice—in some cases a statutory requirement—whose object is the removal or partial removal of the hardening and embrittlement produced by the strains and shocks to which chains are subjected in practice. The main object of the present research is to study the effects of, firstly, low-temperature annealing (650 to 760 deg. C.), and, secondly, normalising, upon the mechanical properties of chains which have been subjected to varying degrees of plastic strain.

The work performed to date includes the following:—A $\frac{3}{4}$-in. chain, in the condition in which it was received from the manufacturers and the proving house, has been subjected to a number of overstrainings produced by either static tensile loading or impact tensile loading. One, two and three overstrainings were employed, with intermediate and final heat treatments. Suitable tests have been made to determine the mechanical properties of the chain as a whole, and of material cut from chain links at positions removed from the weld. These tests led to the following conclusions:—(1) Where static tensile overstraining forces were employed—(*a*) The total energy to fracture of a chain subjected to repeated straining, followed after each strain by either annealing or normalising, is much greater than the energy to fracture of a sample which has not been subjected to intermediate heat treatment. The final breaking load remains, however, generally unchanged. Normalising possesses no advantages over annealing in this respect, both being regarded as satisfactory treatments. (*b*) Although repeated overstrainings and annealings produce a somewhat reduced value of the tensile strength of the material of which the chain is composed, no indication of any "shortness" is disclosed by a static tensile test. (*c*) Tensile impact tests made on specimens cut from links and normalised on receipt at the Laboratory, showed that the energy absorbed to fracture was somewhat reduced by a combination of overstrainings and annealings. In no case, however, did this value fall below that of the material in the condition "as received" (*i.e.*, after manufacture and a single "proofing"). Intermediate and/or a final normalising treatment somewhat improved this value. (*d*) Notched-bar tests made on specimens cut from chain links showed that the energy absorbed to fracture is greatly reduced by repeated overstrainings followed by annealings. A final normalising process tends to restore the material.

(2) Where tensile impact overstraining forces were employed—(*a*) In the tensile impact tests to destruction the fact was clearly brought out that a progressive deterioration of the welded portions of the link took place due to the shocks employed in the overstraining processes. In nearly every case fracture finally occurred at a welded joint. The intermediate heat treatment, whether normalising or annealing, had of course no effect on this deterioration. In the few cases where failure did not occur at the weld, the values of the energies to fracture showed that combinations of overstrainings and annealings had not produced any brittleness in the chain as a unit. (*b*) As in the case of chains subjected to static tensile overstraining, tensile and tensile impact tests made on specimens cut from chain links failed to show any marked deterioration in the properties of the material due to combinations of overstraining and annealing.

Never prophesy till you know; be cocksure when you see the castings.—*Buchanan.*

Cast Iron for Electrical Machines.*

By J. H. Partridge, B.Sc. (Hons), (University of Birmingham).

The paper is divided into five sections:—(1) Introduction; (2) explanation of terms; (3) industrial requirements; (4) experimental—(*a*) the effect of silicon; (*b*) the effect of manganese; (*c*) the effect of aluminium; (*d*) the effect of chromium; (*e*) non-magnetic alloys; (*f*) malleable cast iron; and (*g*) the relationship between the structure of cast iron and its magnetic properties—and (5) summary and conclusions.

In the experimental section, sub-sections (*a*) and (c), reference is made to a fifteen minutes' anneal at 900 deg. C. before machining. This annealing appears to be an erratic procedure, and is due to the author being influenced by the customary procedure in testing ferro-magnetic materials and also by the work of Dr. Nathusius, who annealed all his specimens for 24 hours at 900 deg. C. before testing. The author realises, of course, that cast iron, having certain desirable properties when in the cast state, is far more valuable and useful than cast iron having similar properties when in the annealed condition.

Introduction.

Twenty years ago the frames and housings of electric motors and generators were constructed of cast iron. It was found that cast steel was magnetically superior to cast iron; cast steel housings were readily adopted by designers, and in a few years it had almost entirely replaced cast iron for electric machinery. There was very little information on the magnetic properties of cast iron. Designers condemned it without investigating its properties, without giving it a chance to defend itself.

This investigation, carried out at the instigation and under the direction of Professor T. Turner, is not intended to be a treatise on this subject, but serves to show the effect of some of the common elements on the magnetic properties of cast iron and to show that this material has a promising future in the electrical industry. It definitely disproves the old idea that cast iron does not have any useful magnetic properties.

Explanation of the Terms.

As this subject is rather more physical than metallurgical, it is necessary to explain a few of the terms used in magnetism. The entire space round a magnet in any part of which it is possible to detect magnetic force due to the magnet is called the magnetic field of that magnet. The intensity of such a magnetic field at any particular point is determined by the force exerted on a unit pole placed at that point. If the unit pole moves so that the direction it takes is, at every instant, the direction in which the magnetic force acts, the course it takes through space is called a line of magnetic force. In general these lines are curved, for the direction of the magnetic force varies, as the unit pole passes from point to point through the field. The well-known curves in which iron filings group themselves when scattered round a bar magnet represent approximately the forms taken by the lines of force. For a bar-magnet the lines of force start from the positive pole, bend round in curves, and converge on the negative pole. Now if the magnet is broken across, each piece becomes a magnet, and there are lines of force across the gap. Consequently, the lines of force must be regarded as being continuous closed curves, part being in the metal itself and part being in the air. That part of the line of force in the metal is known as a *line of magnetisation*, or a manwell. In a uniform field —that is to say, a field in which the magnetic force has the same direction and the same intensity at all points—the lines of force are straight, parallel and equally spaced, and the strength of the field is equal to the number of lines of force crossing one sq. cm. perpendicular to the direction of the force, and is generally denoted by the letter H. If a piece of brass be placed in this field the field does not change; the same number of lines force pass through the brass as through an equal area of surrounding air. If, however, a piece of iron is placed in the field the latter is distorted and more lines of force pass through the iron than through an equal area of surrounding air. In other words, the lines of force prefer the path through the iron, which may be said to be a better magnetic inductor than the surrounding air. The very fact that there are extra lines of force passing through the iron causes it to become a magnet, and indeed the strength of this magnet is proportional to the number of these extra lines of magnetisation which traverse it. The total number of lines of magnetisation traversing the iron, divided by its area, is known as the *magnetic induction*, generally denoted by B: *i.e., B is the magnetic induction per sq. cm.* Since there are

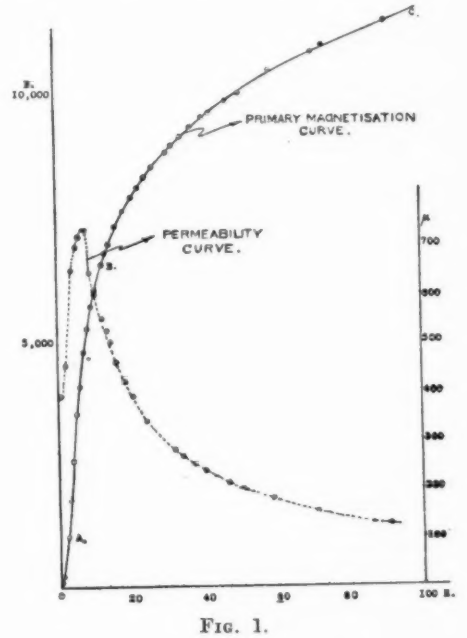


FIG. 1.

no extra lines of force induced in brass, it does not become magnetised; the number of lines of magnetisation per sq. cm. within the brass specimen is always equal to the number of lines per sq. cm. in the field, i.e., B = H. For iron, however, B is very much greater than H. This may be expressed by saying that iron is more *permeable* with respect to lines of magnetisation than the surrounding air The lines of magnetic induction may be visualised as crowding into the iron, finding an easier path through it than through the air. The quality by virtue of which the iron of the specimen conducts the lines of induction better than the air is called its *magnetic permeability*. Thus the permeability of the iron is the ratio of the number of lines of induction per sq. cm. in the specimen (*i.e.*, B) to the number of lines of force per sq. cm. in the air surrounding the rod (*i.e.*, H); thus the permeability $= \frac{B}{H}$ and is generally denoted by μ. Suppose a specimen of iron is subjected to a magnetic force H, and that the magnetic induction produced by this force is B. If the force H is altered in any way the magnetic induction B will also change, and these changes may be represented graphically, as shown in Fig. 1. At first there is little increase in the magnetic induction, as represented by the line OA. Then there is a sharp

* A Paper read before the Annual Conference of Institute of British Foundrymen.

and rapid increase in the induction, as shown by the curve AB, which becomes exceedingly steep; this is the region of maximum permeability shown by the peak on the dotted curve, for obviously if B becomes very large, whilst H only increases a small amount, the ratio $\frac{B}{H}$ must become very large. Lastly, the curve rounds off until the rate of ascent again becomes small and hence the permeability diminishes.

Fig. 2 illustrates that if, when the point C is reached the magnetic force is diminished, the induction does not fall along the curve CBAO, but takes the curve CD instead. Thus when the magnetic force has been reduced to zero, magnetism equal to OD remains in the specimen, and is hence called the *residual* or *remanent magnetism*. If the magnetising force is now reversed a negative force equal to OE is required to reduce the remanent magnetism to zero. Hence OE is a measure of the degree of stability with which the remanent magnetism is held and is known as the *coercive force*. The greater the coercive force the more strongly is the remanent magnetism held, and *vice versa*. On decreasing the force still further, the curve EF is obtained, and if this force is again reduced to zero the induction follows the curve FG. The remanent magnetism OG is equal to the remanence OD, the magnetism simply being in the opposite direction. If now the force is increased to the original positive maximum, the curve GHC is obtained.

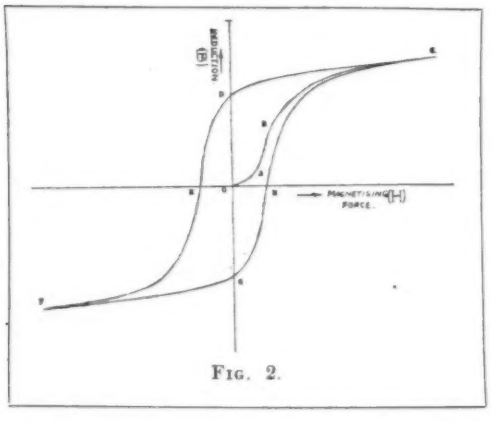


FIG. 2.

Thus it will be seen that on decreasing the magnetic force from a positive value to an equal negative value, and then again increasing it to the original positive value, the induction follows the curve CDEFGHC, and an amount of energy proportional to the area of this curve, or the so-called "*Hysteresis loop*," is dissipated during the process. This energy takes the form of heat, and, consequently, the specimen becomes warm when the magnetism is successively reversed or varied in any way. The cores of transformers and dynamo armatures are familiar instances in point.

This heating, which occurs as a consequence of hysteresis, has, of course, nothing to do with the additional heating which Foucault or eddy currents may cause when quick changes of magnetism take place. Now the area of the loop gives the energy dissipated in ergs per cubic centimetre of the specimen per cycle of magnetisation. Now, ergs per cc. per cycle is rather an inconvenient unit, so that the hysteresis loss has been expressed in watts per lb., assuming the specimen to be subjected to 100 cyclic changes per second. This magnetic hysteresis of iron is very important, as two illustrations will show:—Take the case of a large dynamo with an armature of soft iron weighing 1 ton with a hysteresis loss of, say, 10,000 ergs. per cc. per cycle. If this armature rotates at such a speed that the iron undergoes 100 cyclic changes of magnetisation per second, then 17.7 h.p. is required to overcome the magnetic hysteresis of the iron. Nearly 4,000 cyclic changes of magnetisation would produce a rise in temperature of 1 deg. C. Suppose that the dynamo is a 4-pole machine rotating at 1,000 r.p.m., there are 2,000 cyclic changes per minute—hence the temperature of that armature would rise ½ deg. C. per minute, assuming that there is no radiation or conduction.

Industrial Requirements.

The magnetic properties of any material must suit its industrial requirements. Thus the armatures of D.C. and the stators of A.C. motors and generators must not only possess high permeability but must also have the lowest possible hysteresis loss, since these parts are subjected to an alternating magnetic field. The frames of such D.C. machines and the rotors of A.C. generators must have the greatest possible magnetic permeability, the hysteresis loss being immaterial, since such parts are not subjected to an alternating magnetic field.

The required permeability is especially high in the pole pieces of D.C. machines in order to reduce as far as possible the weight of copper required in the field coils. The pole pieces are sometimes made of wrought iron forgings cast into the C.I. magnet frame and fitted with pole shoes of laminated wrought iron, as shown in Fig. 3.

Sometimes the pole piece and shoe are built up in one piece from wrought-iron laminations and

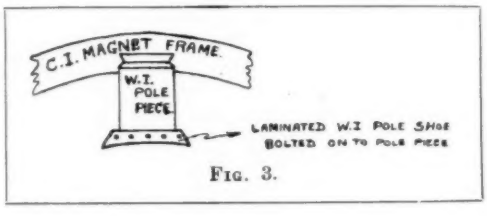


FIG. 3.

bolted to the cast-iron magnet frame. This form gives a pole of rectangular section, whereas the wrought-iron pole piece is almost always of circular section.

Cast iron is never used for pole pieces owing to its low permeability, but occasionally pole pieces and magnet frame are cast together in cast steel and fitted with shoes.

For permanent magnets, however, not only is the greatest remanent magnetism required, but the coercive force must also be as large as possible Soft iron, for example, retains 92 per cent. of its magnetism after the magnetising force has been withdrawn. But since the coercive force of soft iron is only about 2 c.g.s. units, this residual magnetism is held so feebly that even the lightest touch of the fingers suffices to destroy most of it. Consequently, soft iron would not be suitable for a permanent magnet. The best magnets have a coercive force of about 150 c.g.s. units, but such high coercive force is only obtained by sacrificing the remanent magnetism to a certain extent, and an approximation of the value of a material for magnets is obtained from the product of the coercive force and the remanent magnetism. Such a product should be in the neighbourhood of 1,000,000.

For bed plates, end plates for generators and motors, cable bones, shields for motor, etc., a non-magnetic material is desirable in order to minimise the losses due to stray flux.

Cast iron, occasionally qualified by the adjectives "soft" and "hard," is sometimes mentioned in tables of magnetic properties, and from such tables one is led to suppose that it is useless, when viewed from the standpoint of its magnetic properties. It has always been stated that cast iron possesses low induction and low permeability and high hysteresis loss. Values such as 8,000 for the maximum induction at a field strength of 150 c.g.s., 250 c.g.s. for the maximum permeability, 12 c.g.s. for the coercive force, and 35,000 to 40,000 ergs for the hysteresis loss are quoted. However, cast iron offers great possibilities as regards its magnetic properties. Examples are given in this Paper of cast iron with twice this induction, from four to ten times the permeability, and nearly one-tenth the hysteresis loss.

Experimental.

American washed iron of the following analysis was used for the present investigation.

	First supply.	Second supply.
	Per cent.	Per cent.
Total carbon ..	3.16	3.84
Graphite carbon ..	nil	nil
Manganese	Trace	Trace
Silicon	0.046	0.03
Sulphur	0.016	0.02
Phosphorus ..	Trace	Trace

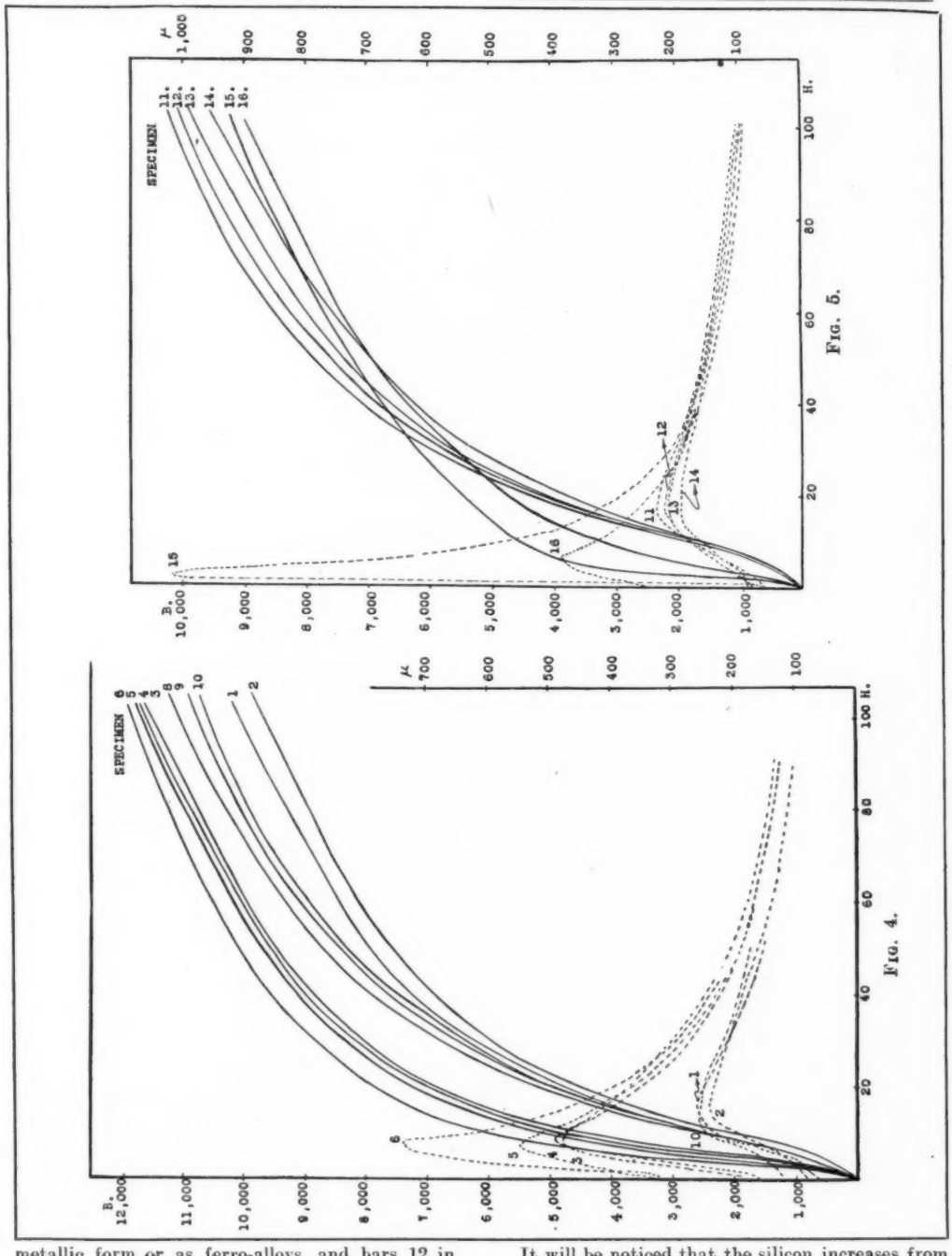
The iron was melted in a 30-lb. salamander crucible, elements were added either in the metallic form or as ferro-alloys, and bars 12 in. by 1 in. diameter were cast in sand-moulds. The bars were machined down to 1.128 centimetre diameter. The primary magnetisation curves were determined by using an Iliovici permeameter, and the hysteresis loops by the bar-and-yoke method.

The Effect of Silicon.

In order to determine the effect of silicon on the magnetic properties of cast iron, bars containing various percentages of this element were cast. The analysis of these bars is given in Table I.

TABLE I.—*Composition of Alloys of the Silicon Series.*

Specimen	T.C.	G.C.	G.C.	Si.	Mn.
1	2.77	1.88	0.89	0.6	0.015
2	2.79	2.14	0.65	0.807	Trace
*3	3.11	0.24	2.87	1.43	0.024
*4	2.95	0.35	2.6	1.97	0.025
*5	2.74	0.46	2.28	2.26	0.02
*6	2.675	0.28	2.42	2.46	Trace
8	2.70	1.46	1.24	2.41	0.04
9	2.58	1.1	1.48	2.745	0.035
10	2.54	1.35	1.19	4.165	0.035



It will be noticed that the silicon increases from 0.6 to 4.0 per cent. With the exception of those bars marked,* all bars were tested in the cast state, without even being annealed to remove machining strains. The bars marked* in this and subsequent tables were annealed at 900 deg. C. for fifteen minutes, and were then turned down to size. Specimen 7 was accidentally broken and was not available for testing magnetically. The magnetisation and permeability curves for all the

specimens are given in Fig. 4, and the magnetic properties are shown in Table II.

Table II.—*Magnetic Properties of the Silicon Series of Alloys.*

Specimen	B max. (Max. magnetic induction.)	H max. (Max. magnetic field strength)	μ max. (Max. permeability.)	H for μ max.	Remanent magnetism.
1.	9,977	99.58	264.0	15.1	5025
2	9,678	99.78	237.0	16.2	4733
*3	11,480	98.9	481.5	8.0	5124
*4	11,644	100.13	497.0	8.0	5523
*5	11,747	100.53	549.0	6.9	4578
*6	11,900	100.3	737.0	7.8	4724
8	11,090	101.43	271.6	16.0	4667
9	10,833	101.43	253.0	16.0	4431
10	10,540	98.36	254.0	14.0	4060

The most prominent feature is the magnetic superiority of the annealed specimens compared with the unannealed ones. The effect of annealing may be seen by comparing specimens 6 and 8 which have almost identical silicon contents. Specimen 6 has been heat treated before turning, but specimen 8 is in the cast condition. The maximum induction of the former is 11,900 c.g.s. whilst that of the latter is 11,090 c.g.s.

The dotted curves in Fig. 4 represent the change of permeability with respect to the field, and it will be noticed that the maximum permeability increases with increasing silicon content, and that the maximum permeability of the annealed specimens is more than twice that of the unannealed ones. The low induction of specimen 2 is due to the high percentage of combined carbon. The magnetic properties of the cast specimens appear to deteriorate with the higher the content of silicon. Thus, specimen 10 is not as good magnetically as specimen 9, which in its turn is not as good as specimen 8. These specimens were not prepared in one heat and they are rather an imperfect series of alloys. Moreover, the casting conditions may have a considerable influence on the magnetic properties of the material. As the author was chiefly concerned at this time with obtaining high permeability and low hysteresis loss, and since it is evident that annealing raises the induction and permeability of cast iron, all the specimens were embedded in their own turnings in a sealed iron box. They were then heated to 875 deg. C. and allowed to cool at the slow rate of 30 deg. C. per hour to 675 deg. C., from which point they were allowed to cool with the muffle. In this way most of the carbon was precipitated as finely divided graphite, the strains due to turning were removed, whilst oxidation was prevented by annealing the specimens in their own turnings. Primary magnetisation curves and hysteresis loops were taken, the results being shown in Tables III and IV. The maximum induction increases with increasing silicon content.

Table III.—*Primary Magnetic Results on the Silicon Series.*

Specimen.	B max.	H max.
1	10,170	99.45
2	9,810	100.0
*3	11,060	98.35
*4	11,320	101.4
*5	11,480	99.1
*6	11,430	99.2
8	11,690	100.5
9	11,570	103.8
10	11,960	99.8

Table IV.—*Other Magnetic Properties of the Silicon Series.*

Specimen.	Coercive force.	Hysteresis loss in ergs/cc. per cycle, for B = 10,000.	Watts loss per lb. of metal.	Density.
2	12.7	34,080	20.997	7.363
*3	9.8	27,680	16.750	7.231
*4	8.5	26,120	16.440	7.213
*5	7.0	23,860	14.898	7.180
*6	6.5	18,850	12.049	7.164
9	7.6	20,120	12.748	7.163
10	3.5	8,700	5.634	7.038

With the exception of specimen 9, the addition of silicon reduces both the hysteresis loss and the coercive force. Moreover, with high silicon content, as in specimen 10, the hysteresis loss is exceptionally low, being nearly as low as that of wrought iron. The last column in the table gives the energy dissipated per lb. of iron, assuming the specimen to be subjected to 100 magnetic cycles per second at a flux density of 10,000 maxwells per sq. cm.

Alloys containing up to about 8 per cent. of silicon were then prepared in one heat and these were tested in the cast state, after turning to a diameter of about 1.170 centimetre and then grinding to a diameter of 1.128 centimetre. The analysis of these specimens is given in Table V.

Table V.—*Composition of High Silicon Series.*

Specimen	Si.	T.C.	C.C.	G.C.	Mn.
11	2.54	3.06	1.35	1.71	0.02
12	2.87	2.97	1.25	1.72	0.03
13	3.41	2.97	1.17	1.80	0.032
14	4.76	2.76	0.88	1.88	0.053
15	6.04	2.61	0.09	2.52	0.085
16	7.38	2.4	0.1	2.3	0.095

Primary magnetisation and permeability curves were taken by using the permeameter and are shown in Fig. 5. A summary of the magnetic properties is given in Table VI.

Table VI.—*The Magnetic Properties of Second Silicon Series.*

Specimen.	B max.	H max.	μ max.	H for μ max.	Remanence.
11	10,190	99.75	230	16.4	4300
12	10,100	100.13	218	16.4	4290
13	9,845	100.2	213	15.2	3800
14	9,455	100.13	193	20.48	2900
15	9,200	99.71	1,021	2.25	2900
16	8,935	97.3	383	5.88	1650

Thus silicon decreases the magnetic induction and the remanence, and, when present in amounts not exceeding 5 per cent., it also decreases the maximum permeability of cast iron in the cast state. On referring to Fig. 5, it will be noticed that specimens 15 and 16 are much more magnetic than the other specimens in comparatively weak fields. This property is reflected in the permeability curves, the permeability of specimen 15 being 1,021 c.g.s. at a force of only 2.25 c.g.s.

This is a property common to alloys possessing very low hysteresis loss, namely, they are very permeable in weak fields, but they are not any more permeable than ordinary alloys in strong fields.

Hysteresis loops were next determined, and the magnetic properties are given in Table VII. Owing to the magnetic hardness of some of the specimens, the hysteresis loops could not be determined between the limits of B=10,000 maxwells. The limits of induction between which the loops were determined are given in the first column of Table VII. However, it must not be supposed that the hysteresis loss is directly proportional to the limits of induction between which the loop is determined, since the loop becomes very narrow at its extremities.

Table VII.—*Hysteresis Loss on Second Silicon Series.*

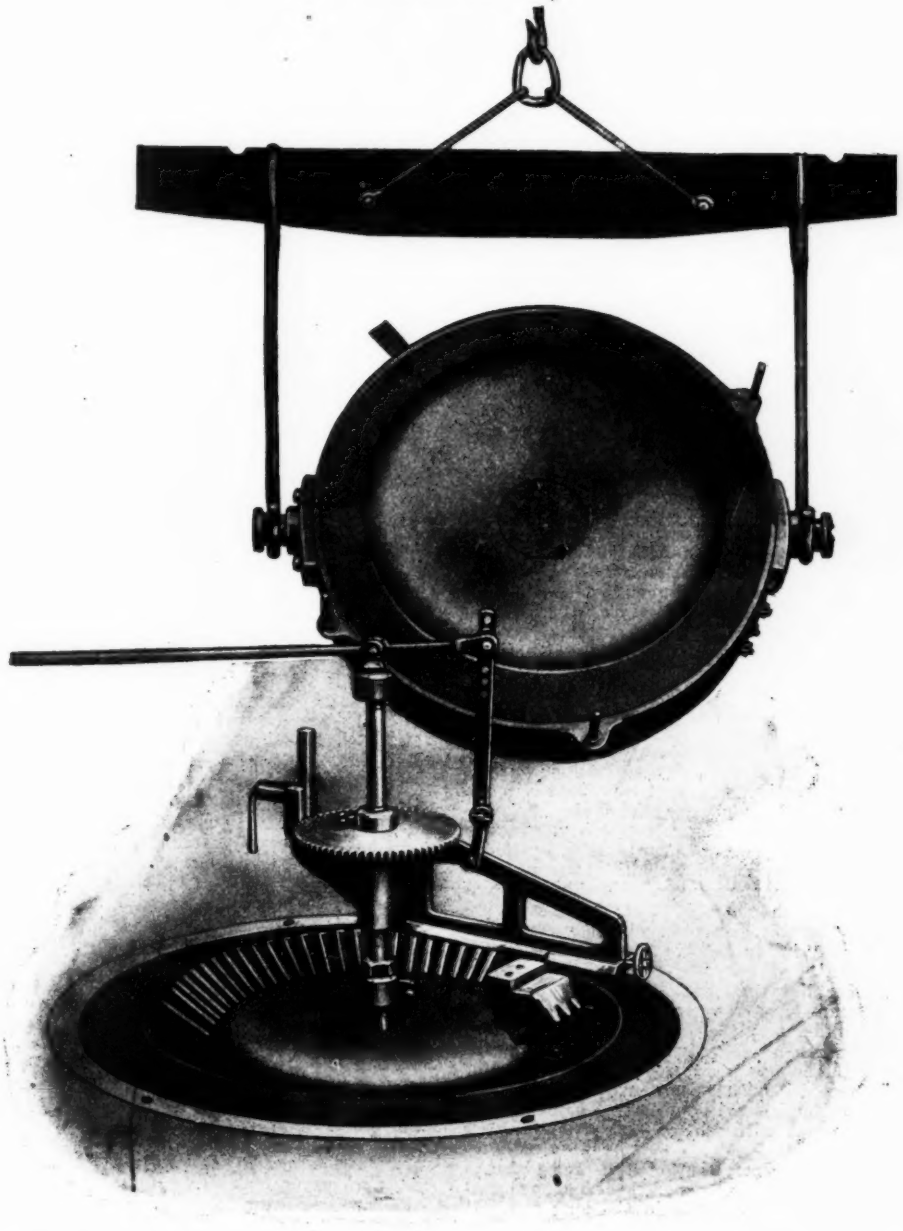
Specimen.	Limits of induction.	Coercive force.	Hysteresis loss ergs/c.c. per cycle.	Watts loss per lb.	Density.
11	10,000	12.7	32,435	9.984	7.225
12	10,000	13.1	32,900	20.19	7.238
13	10,000	12.0	28,700	18.02	7.221
14	10,000	9.8	22,840	14.50	7.143
15	8,000	2.2	4,075	2.652	6.951
16	4,500	1.7	2,390	1.551	6.949

Thus, with the exception of specimen 11, silicon reduces the coercive force and the hysteresis loss. The hysteresis loss of specimen 15 is exceptionally low, and it is remarkable since it occurs in an alloy which is in the cast state.

(To be continued.)

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,
(MANCHESTER), LIMITED,
BLACKFRIARS, MANCHESTER.

Drawing Office and Pattern Shop.

All practical men have had the experience, when constructing or supervising a job with intricate and involved coring, of discovering after the pattern has been made, and perhaps most of the core-boxes, that an important alteration is necessary to ease the moulder's task, or render the work suitable for machine moulding.

It is very nearly impossible to visualise accurately what a casting will be like before the pattern is made. Even small bosses and ribs frequently look altogether different from what the designer intended, and the pattern-maker, from his presumably wide experience of foundry work, can often suggest valuable modifications. Consequently, it is frequently advisable for the draughtsman to consult with the patternmaker.

Simplicity in design cannot be too rigidly enforced, and it is generally recognised that designs have become in many cases too intricate. The development of the internal combustion engine has had much to do with this, but if manufacturing costs have to be kept at a reasonable figure designs should be as simple as possible. Upon occasion, the pattern-making and moulding costs of a job may be halved by one or two comparatively simple alterations, and it will be found of immeasurable value to aim at a friendly spirit between the pattern shop and the drawing office.

Indeed, no two departments should be so continually in contact with one another in an engineering works as the drawing office and the pattern-shop. It is in the pattern-shop that the designer sees his work assuming shape, and it is there also that he most frequently makes modifications. The pattern becomes an experimental model. It is no uncommon thing, either, for the patternmaker to discover inaccuracies on a drawing.

It is difficult to say to what extent the draughtsman should supervise the patternshop. It is sometimes suggested that the draughtsman's supervision should extend to the quality of the material and the methods of construction, but for various reasons this attitude is not always advisable. Very few draughtsmen have the intimate knowledge of foundry requirements which is essential for the determination of construction methods, and certainly this should be within the province of the foreman patternmaker. Further, there is nothing to which the skilled craftsman is more liable to take objection than what he chooses to consider as "instruction in the routine details of his craft."

It is certainly not sufficient that the chief draughtsman should occasionally walk through this shop and survey the work under construction. The draughtsman actually responsible for the work should be easily accessible, and should not only have occasional examinations of the pattern or patterns, but should be able and willing to go down to consult with the foreman patternmaker when required.

Although the supervision of the draughtsman may add to the initial expenses of pattern-making, it will prove profitable in the long run. It is, unfortunately, the policy of some patternshops to ignore any mistakes which the draughtsman may have made, as they consider it is no business of theirs to draw attention to an obviously incorrect dimension or to suggest a modification. This deplorably shortsighted policy will be found considerably more expensive than any amount of supervision exercised by the draughtsman.

It is sometimes customary for the draughtsman to measure work before it goes to the foundry, and if this is the case, he should certainly insist on templates. It is very doubtful if it is wise for the draughtsman to supplant the foreman patternmaker as a checker, as there are many allowances on patterns which are only in force as the result of long experience; and even if the draughtsman has had this experience and is an efficient checker, there is a tendency for a department to become careless when another department has to accept responsibility for its work. In this respect, however, it is advisable that the draughtsman should make a very careful examination in order to assure himself that there has been no departure from his drawings or instructions.

Associated Problems.

It is not quite easy to follow the patternmaker's ideas on intricate work. The pattern may have only a slight resemblance to the finished casting, and to facilitate coring it is frequently necessary to make peculiar joinings or to place cores within cores. Bad pattern-making, it should always be remembered, is a relative term. Bad pattern-making for one class of work may be very good pattern-making for another class.

As is generally recognised, the quality of timber used and the degree of finish should depend on the class of pattern wanted, and for quantity production the best material and workmanship are essential.

Every part of the pattern and core-box should be tapered and filleted in order that delivery from the sand will be a simple matter. Inaccurate castings and damaged patterns result when the moulder has to use a hammer to obtain delivery from the sand. When only one or two castings are required, or when the metal is fairly thick, much may be left to the moulder; but, with repetition work and light work, the radius of every fillet is important, and even small corners should not be rounded without the use of a template.

Taper is a common source of trouble to the moulder. Patternmakers invariably taper their work, even if it also means tapering core-boxes to retain the required metal thickness, but sometimes because of a machined face they cannot do so without first consulting the draughtsman. If this has been considered in the first place confusion may be saved in the other shops.

It is a practice not uncommon among patternmakers when there is difficulty in supporting a core, to core small diameter holes which are afterwards plugged. This procedure is very objectionable, and the draughtsman should see that it is unnecessary. This is a point on which the experience of the patternmaker is very valuable. The draughtsman may decide that there is a sufficient number of prints to support the core, but it is sometimes necessary to break the core into different parts, when this would not be so. It may be possible, however, by a slight modification, to overcome this difficulty.

In this connection, quick changes in metal thicknesses that may result in fracture are often noted in the pattern shop. An additional rib, for instance, may greatly facilitate the flow of metal and equalise contraction strains. On the other hand, patternmakers will sometimes leave bosses to be bored when it would have been far easier to core them.

A high-class pattern for repetition work should be so constructed that every loose piece may be replaced without measuring when a mould has to be made. The only effective way of doing this is to eliminate loose pieces as much as possible and to use dovetails when pieces should be left loose. When parts of a pattern are screwed, nailed, or wired, as often as not the moulder will rap them out of position, and the draughtsman is justified in insisting on the use of dovetails whenever possible.

Drawbacks are a continual if unavoidable source of waste of time in the foundry. In large work, especially for "one-off" jobs, it is not always practicable to dispense with them. It may be economical to leave the moulder to mould a part of a job in a drawback, because of the cost of making the part loose, or using a block print and core-box, but it is altogether different with small work.

For repetition work and nearly all small work drawbacks are avoidable. The patternmaker may have difficulty in constructing work to the drawing, so that these are unnecessary; but in many cases he will be able to suggest an alteration that will simplify without affecting the main principles of design, and will enable the pattern to deliver freely from the sand.

There are many ways in which the draughtsman can guard against mistakes and at the same time assist the patternmaker. For one thing, all the most difficult shapes should be developed in the drawing office; for instance, it is of great assistance in the patternshop if a number of scrap views are shown, and this plan will also save a considerable amount of time.

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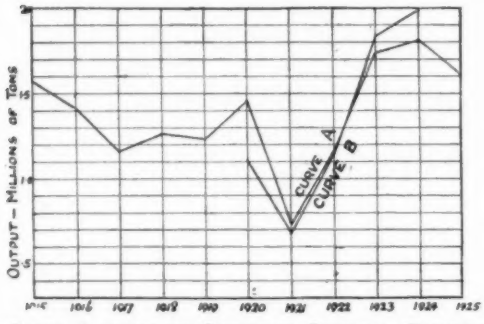
The Statistics of Ironfounding.

FROM A CORRESPONDENT.

The publication of the annual statistical compilation of the National Federation of Iron and Steel Manufacturers* should remind ironfounders and metallurgists of the importance of such figures, which serve to show the extent and fluctuation of trade activity during the year in this and other countries, and the



CURVE A SHOWS THE SCHEDULED OUTPUT OF FOUNDRY PIG-IRON FROM 1915-25, AND CURVE B, THE SAME CORRECTED BETWEEN 1920-24.

relative progress being made by the various metallurgical processes.

Scanty as they are, the figures relating to ironfounding are of peculiar interest. It is still a matter for argument as to whether the use of cast iron is increasing or diminishing. Every founder, every moulder, is deeply concerned as to whether the industry is advancing or declining, and yet, as was pointed out in a

TABLE I.

	1924.	1923.	1922.	1921.	1920.
Acid pig produced ..	2.34	2.431	1.571	0.842	2.942
Add imports ..	0.003	0.001	nil	0.009	0.012
	2.343	2.432	1.571	0.851	2.954
Less exports ..	0.195	0.260	0.242	0.051	0.188
	2.148	2.172	1.329	0.800	2.766
Pig used for Acid steel	1.558	1.498	0.919	0.785	2.602
Excess	0.590	0.674	0.410	0.015	0.164
Basic pig produced ..	2.445	2.422	1.570	0.700	2.662
Add imports ..	0.171	0.039	0.095	0.255	0.152
	2.616	2.461	1.665	0.955	2.814
Less exports ..	0.007	0.005	0.008	0.001	0.009
	2.609	2.456	1.657	0.954	2.805
Pig used for basic steel ..	2.923	2.818	1.917	1.207	3.217
Excess	0.314	0.362	0.260	0.253	0.412

recent Paper to the Institution of Mechanical Engineers,‡ it is impossible to tell from the figures how the industry is progressing. No statistics are available to show the output of either grey iron or malleable iron, or of exports or imports of these materials. Since 1915, however, in the returns of the N.F.I.S.M., the output of foundry pig has been obtained separately from that of forge pig, and the foundry pig figures are given graphically in the annexed cut.

It was shown in the above-mentioned Paper that in the United States the foundry pig-iron production was, in 1903, 1913 and 1923 respectively, years chosen to minimise as much as possible the influence of the war, 24.4 per cent., 16.4 per cent., and 14.3 per cent. of the total pig-iron production in that country. Thus foundry pig represents a progressively diminishing part of the total pig-iron output. On the other hand, malleable castings for the same years gave 2.6 per cent., 3.2 per cent., and 3.6 per cent. of the total pig production, and steel castings 2.4 per cent., 3.3 per cent., and 3.6 per cent., showing that these two materials were absorbing a progressively larger fraction of the total pig made. War influences apart, there seems to be no escape from the conclusion that the production of grey iron castings is virtually stationary, if not declining, both in Great Britain and in America, and in this country it is also probable that malleable iron would also show a decline were the figures available. Thus over a period of years in which unexampled developments have taken place in the engineering industry, the progress made in every other branch of metallurgical work has not

TABLE II.

	1924.	1923.	1922.	1921.	1920.
Foundry Pig Output ..	1.803	1.733	1.166	.747	1.457
Add Imports ..	0.057	.026	0.029	0.206	0.025
	1.860	1.759	1.195	0.953	1.482
Less Exports	0.141	0.230	0.200	0.206	0.133
	0.719	1.529	0.995	0.927	1.349
Add Acid pig not used in steel making	0.590	0.674	0.410	0.015	0.164
	2.309	2.203	1.405	0.942	1.513
Less pig required to make up basic steel output	0.314	0.362	0.260	0.253	0.412
Actual foundry pig used for grey iron ..	1.995	1.841	1.145	0.689	1.101

been shared by the founding industry. The effect of this is much too large a subject to examine in detail, but it means in the long run that a foundry increasing its output can only do so at the expense of other foundries in the country, and that there is lacking that natural expansion and growth of markets which provides a satisfactory solution to the ambitions of those engaged in an industry and the natural desire for promotion and advancement on the part of those employed in it. There is every nope, however, that recent important developments may provide that natural expansion which is so desirable.,

It is merely desired at this point to urge the importance of adequate authoritative statistics as a means of enabling those in the industry to judge of its progress. Since 1915 the official returns have separated the production of forge pig and foundry pig. We suggest that this separation should be given in the table for the output of pig-iron instead of giving foundry and forge pig bracketed together. It is also desirable that these two grades should be separated in the statistics for pig imports and exports. It is fully recognised that difficulty is occasionally experienced in grading pig, and that iron produced for and even scheduled as foundry pig may be used for forge purposes.

In addition to this it is highly desirable that an attempt be made to show the British output of grey iron and malleable iron, together with import and export figures.

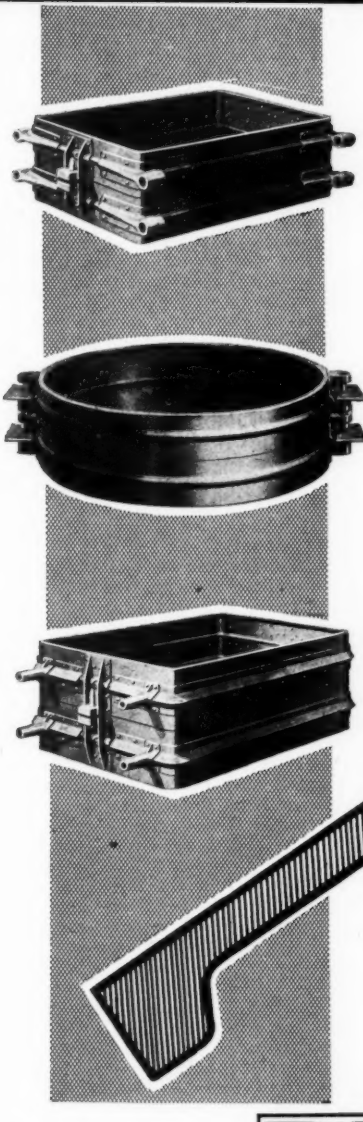
British Monthly Output of Steel Castings in 1,000's *of tons :*

	1926.	1925.	1924.	1923.	1922.	1921.	1920.		1925.	1924.	1923.	1922.	1921.	1920.
January	11.0	13.3	12.7	9.9	6.2	15.1	—	July ..	13.4	15.3	11.7	7.7	6.4	18.5
February	12.9	14.0	16.0	11.6	7.9	15.5	17.9	August	11.0	12.7	13.0	8.6	9.4	17.3
March	14.2	13.6	16.1	13.6	7.4	14.2	19.0	September	12.8	14.0	13.6	9.5	9.2	19.0
April ..	11.0	12.4	14.6	12.6	4.9	6.4	17.0	October	12.5	15.1	13.3	9.4	8.2	16.4
May ..	—	13.7	16.6	14.3	3.6	2.2	18.0	November	11.6	13.9	14.8	9.1	7.7	16.2
June	—	11.5	13.8	13.8	4.9	1.9	16.0	December	12.1	12.8	11.9	7.9	7.2	18.0

The output of foundry pig does not, of course, of itself give a sufficiently close indication of the amount actually used in the foundries of Great Britain, and a figure for the output of grey iron castings would give some idea of the extent to which scrap is employed. The figure for the output of the foundry pig-iron requires adjustment for imports and exports. Then some foundry pig-iron is used for steel making, while pig classed as hematite is used to some extent in foundry work. An attempt has been made in the

* Statistics of the Iron and Steel Industry (1924). N.F.I.S.M., Caxton House, Westminster.

† Cast-Iron and Modern Engineering Practice, by J. G. Pearce, Dec., 1925.



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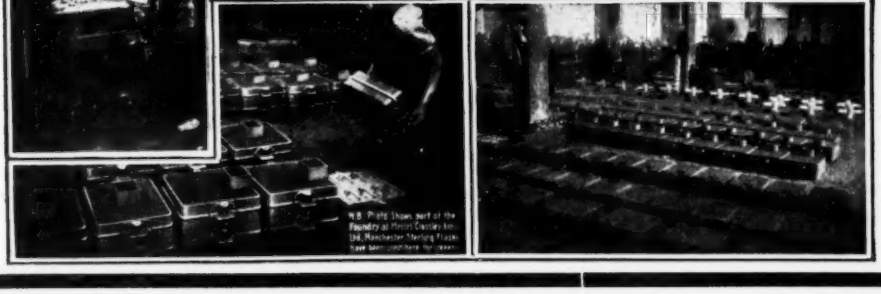

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tables given to ascertain for a series of years for which the necessary figures are available the actual amount of foundry pig-iron employed each year for foundry purposes, and the results are plotted in Fig. 1 to show comparison with the actual quoted figure for foundry pig-iron output. The results cannot be taken as more than illustrative, for no figures for stocks in hand are available. Furthermore, as foundry and forge pig are at present included together in the import and export figures, the foundry figure has been taken as one-half in each case. Forge pig fluctuations are much too erratic to permit a closer treatment. The figures in the tables represent millions of tons, and it is assumed that acid pig over and above that required for steel-making is used in founding, and that pig used for basic steel manufacture over and above the requirements for basic pig is drawn from foundry pig.

The natural fluctuations in the industry and consequently its condition could be infinitely better assessed if additional figures were available, and there does not appear to be any insuperable difficulty in ascertaining them. The figures required cover the annual British output, the imports and exports of cast iron and malleable iron; in the latter case the figures require differentiating for blackheart and whiteheart. It would be advisable to confine the import and export figures at present to castings in the raw and machined state. Castings actually built up or incorporated into machines might be excluded.

The statistics issued by the National Federation of Iron and Steel Manufacturers, however, include the monthly output of steel castings, from which we have compiled the appended table showing the production each month since 1920.—[ED., F.T.J.]

Service Conditions of Refractories for Open-Hearth Steel Furnaces.

In Bulletin 23 of Mining and Metallurgical Investigations, carried out under the auspices of the Carnegie Institute of Technology, the U.S. Bureau of Mines, and Mining and Metallurgical Advisory Boards, an attempt is made to picture as clearly and accurately as possible the conditions of service which affect the use and wear of refractory materials used in the construction of open-hearth steel furnaces.

Under "General Conclusions" some of the more important fundamental conditions which must be considered in any further developments in either the testing and making of refractory bodies or in furnace design are summarised:—

(1) The formation of finely divided fluxing oxides from the bath is an apparently inherent result of the open-hearth process. Iron oxide, approximately Fe_3O_4 in composition, is the principal constituent of these dusts. They are formed largely by (*a*) the spitting of the metal as it melts or boils in an oxidising atmosphere, and (*b*) the oxidation and condensation of vapours of metals coming from the molten steel. Smaller amounts of manganese oxide, silica, magnesia, and lime are also present, the latter two being formed by the dusting of lime and dolomite. Very few of the flux particles come from the slag layer.

(2) The size of most of these particles varies from about 20 microns (0.02 mm.) in diameter down to colloidal sizes. They are easily carried in suspension in the stream of waste gases, varying in concentration from a maximum of 3 to 4 grammes per 100 cub. ft. of gases in the port ends down to a few tenths of a gramme per 100 cub. ft. of the gases in the stack.

(3) Silica and iron oxide (Fe_3O_4) do not seem to form compounds, but at open-hearth operating temperatures apparently dissolve in each other and form solutions with low viscosities, from which magnetite and cristobalite are precipitated on cooling.

(4) During the first week or so of a furnace campaign the porous silica bricks absorb the liquid phase formed from oxide particles and silica and re-crystallise into a definite zone structure. The softening range of the flux-saturated zones is 60 to 120 deg. Fah. lower than of the original brick body. Fluxing is then localised at the saturated brick surfaces, the liquid phase dripping slowly away into the bath or slag pockets. This surface corrosion may be called the "normal" mode of deterioration of the furnace walls.

(5) The minimum softening range of flux-saturated silica bricks is about 2,975 to 3,000 deg. Fah. Sharp working furnaces normally finish their heats with roof surface temperatures around 2,925 to 2,950 deg. Fah. Under these conditions only a slight overheating will cause more or less softening and dripping of the roof surface. This frequently occurs in most furnaces.

(6) At steel-making temperatures, the rapid interchange of heat by radiation tends to keep the various surfaces of roof, walls, bath, etc., at very nearly the same temperatures unless one surface is absorbing heat rapidly—that is, the charge during the melting period. During the refining period of the heat, when the metal is covered with a layer of slag, the temperatures of the melting-chamber surfaces are almost uniform. The melting chamber then becomes very nearly a perfect "black body," and optical temperature measurements taken through a small opening *with the flame off* are closely accurate. Because of flame reflections, "flame-on" temperatures are high; this error is extremely variable, from 10 to 300 deg. Fah.

(7) Heat interchange between melting-chamber surfaces at open-hearth temperatures is very rapid in comparison to rates of heat loss by conduction through the walls. Also, inner-brick surfaces must be held in the range of 2,750 to 2,950 deg. Fah. to obtain rapid melting and finishing of the charge. From these two conditions and other data, the following conclusions are drawn: (*a*) Ordinary variations in furnace temperature affect only the inner zones of the bricks and are almost independent of outside temperatures or wall thickness. (*b*) Water-cooling or air-cooling of refractory walls have very little effect upon inner surface temperatures or upon the rate of wall deterioration by flux corrosion or fusion. Conversely, good insulation of walls should not necessarily raise their inner surface temperatures. (*c*) Most of the heat transfer in the melting chamber is by radiation, which tends to produce uniform temperature distribution. However, any definite current of flame or hot gases deflected against any area in a roof or wall will furnish an added supply of heat to this area and cause local overheating.

(8) The following problems seem worthy of study in connection with the more general problem of open-hearth refractories: (*a*) Vapour pressure of iron at temperatures above its melting point. (*b*) Relations in the systems Fe_3O_4-SiO_2 and FeO-SiO_2 and the effect of lime on these systems. (*c*) Effects of open-hearth chequer deposits on various refractory bodies in different temperature ranges. (*d*) Physical changes occurring in chrome, magnesite, and various special refractories during open-hearth service. (*e*) Decrease in viscosities of new and used refractory bodies at temperatures close to their melting points.

(9) Insulation, oxygen-enrichment, and the minimising of water-cooling are the logical methods for improving open-hearth efficiencies and would certainly be used if we possessed refractories of higher melting points. Even with silica refractories, however, it should be possible to apply such methods to a large extent. Such improvements in efficiency should tend to lighten the burden on refractories by (*a*) steadying furnace operation, (*b*) lowering gas volume and velocities, and (*c*) decreasing the amount of fluxing oxides carried to wall and chequer surfaces.

(10) Research in the development of new or improved refractory bodies and standard tests therefore should continue regardless of whether such new products prove to be of immediate practical value in present open-hearth furnaces or not. Improvements in refractory bodies, increase in service life of refractories, more accurate furnace control, and improved design and furnace efficiency are all closely related and interdependent factors. Much of the possible improvement in furnace design depends upon development of better refractories. Conversely, new refractories and methods of construction will probably show their full value only when used in furnaces designed to give better efficiency in the use of heat and operating time.

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Trade Talk.

H. R. MORGAN, LIMITED, have removed to 8 to 9, Castle Buildings, Swansea.

THE TYRE MILL at the United Steel Companies' works at Workington was restarted last week.

LLOYD, BATEMAN & COMPANY, LIMITED, have removed to 39, Lisson Street, Edgware Road, London, N.W.1.

THE GENERAL ELECTRIC COMPANY OF INDIA have secured one of the largest orders for electrical plant ever placed in India. The order is for the complete equipment of a new power house at Lucknow for the East Indian Railway.

WORKMAN, CLARK & COMPANY, LIMITED, Belfast, have secured an order from Furness, Withy & Company, Limited, London, for a high-class passenger liner for the service between New York and Bermuda. This vessel, which will be 530 ft. long, will have motor engines of the Sulzer type.

CAMMELL, LAIRD & COMPANY, LIMITED, of Birkenhead, have received an order from Elders & Fyffes for the construction of three boats for the conveyance of fruit. Two of them will be 400 ft. long, 50 ft. broad and 33 ft. deep, and the third will be 300 ft. long, 44 ft. broad and 25 ft. deep. One of the vessels is to be delivered in October and the other two in the spring.

THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, have entered into an arrangement with the General Railway Signal Company, Rochester, U.S.A., for the establishment at the Trafford Park Works of plant and machinery for the manufacture of all types of railway signalling apparatus. A new company, called the Metropolitan-Vickers G.R.S., Limited, has been formed.

WITH THE EXCEPTION of a short period during the general strike, the Normanby Park Works of John Lysaght, Limited, have kept their blast furnace plant continuously running. Up to May 30 the company had three of their largest furnaces in operation, and at the present moment two are in blast, and it is hoped that these will continue working for some time to come. They are at the present moment engaged on the manufacture of special foundry iron.

THE ORDER for a complete new plant for the manufacture of weldless steel tubes has been secured by the Wellman Seaver Rolling Mill Company, Limited, which is a subsidiary company to the Wellman Smith Owen Engineering Corporation, Limited. The value of this contract approaches £100,000, and the whole of the plant will be made in the firm's works at Darlaston, Staffordshire, which have been especially equipped for the manufacture of all kinds of steel-works machinery. The thorough modernisation of the Darlaston Works has enabled the firm to successfully compete with Continental engineers.

THE COUNCIL of the Institution of Civil Engineers have recently made the following awards in respect of papers read and discussed at the ordinary meetings during the session 1925-1926:—A Telford gold medal to Mr. O. L. Prowde (Makwar, Sudan); a Watt gold medal to Mr. H. R. Lupton (Leeds); Telford premiums to Messrs. A. S. Angwin, A. Honeysett, T. Walmsley and V. Bayley (London); C. F. Bengough (Tewkesbury), J. N. Reeson (Melbourne, Victoria) and H. A. Reed (Manchester); and a Crampton prize to Colonel G. R. Hearn (Calcutta). The council have also awarded, the Coopers Hill War Memorial Prize for 1925 to Mr. E. L. Everatt (Bombay).

Contracts Open.

Leeds, June 19.—Cast-iron pipes, wrought-iron tubes and fittings; iron castings; merchant iron and steel; bolts and nuts; gas and pipe hooks; tinplates, black and galvanised iron; shovels, coke forks, and files; for the Gas Committee. Mr. C. S. Shapley, engineer and general manager, Gas Offices, Market Hall, Leeds.

London, S.E.1, June 22.—(1) Steel sleepers, (2) steel distance pieces for rails, (3) steel keys for rails, and (4) switches and crossings, for the Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, London, S.E.1.

Wellington, New Zealand, November 2.—Supply and erection of two pipe lines, each approximately 3,655 feet long, for the Public Works Department. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Ref. A.X. 3,210.)

MR. C. STIRLING has been appointed manager of the spring department at the Stocksbridge Works of Samuel Fox & Company, Limited, in succession to Mr. S. Hampshire, who has been appointed works manager of the Don Spring Works, Rotherham, of Edwin Cottam & Company, Limited.

Company Meetings.

British Empire Steel Corporation, Limited. — MR. R. M. WOLVIN, president of the British Empire Steel Corporation, presenting the annual report for the year ended December last, said: "Unsatisfactory operating conditions have impelled the directors to recommend reorganisation, and special general meetings of shareholders will be called for the purpose." In respect of the Dominion Iron & Steel Company, Mr. Wolvin stated that the scope and form of such reorganisation must be guided by the bondholders rather than by the shareholders, and he forecast that the interest and sinking fund payments on the bonds of the company were not likely to be paid when they fell due on July 1. The combined working capital of the British Empire Steel Corporation was reduced during the year from $13,000,000 to $9,500,000. Mr. Wolvin attributed the difficulties of the Nova Scotia steel companies to the increased cost of coal, the low protective tariffs, which gave Canadian manufacturers little advantage over foreign producers, the division of the available market in Canada with foreign producers, and the consequent inability of Canadian producers to conduct large scale operations with a proportionate reduction in costs.

Whessoe Foundry and Engineering Company, Limited.—The sixth annual meeting of the Whessoe Foundry and Engineering Company, Limited, was held on June 8, at 8, Frederick's Place, Old Jewry, E.C. MR. H. G. JUDD (the chairman), who presided, said that the past year was characterised by even more difficulty than its predecessors. The condition of the great basic industries of coal, iron and steel, and shipbuilding, as embodied in the phrase "passed their dividend," was all too familiar, and reflected the severity of the competition for business. That undue competition arose not merely from the paucity of contracts at home, but also from the disadvantage under which this country laboured in comparison with others where depreciated currencies and less stringent conditions of labour obtained. The result had been that, in order to keep the works reasonably well employed, they had had to take orders at prices that often yielded little margin of profit, and in some cases none at all. They had, however, secured a fair share of what trade there was, and by careful management had been able to earn what in the circumstances was, he thought, a reasonably good return. During the comparatively slack time advantage had been taken of the opportunity to carry out certain changes and renovations in the works, which had considerably improved the lay-out and the accommodation, and put them in a position to cope even more efficiently with the larger volume of work which must come to them sooner or later.

Siemens Bros. & Company, Limited. — Gratifying progress and a favourable financial position was the gist of the speech of MR. G. MURE RITCHIE, who presided at the 45th annual meeting of this company. He said that the 1925 results were satisfactory. They could not have been attained without a sound and progressive policy, adequate capital, good plant, efficient management and friendly co-operation on the part of employees generally, but those advantages by themselves could not have produced such a balance-sheet. They all know of many other companies in different lines of industry possessing all such advantages in equal degree, but nevertheless showing meagre profits or indeed large losses. Why? Because they had lacked the one additional thing needful which fortunately Siemens had had, and that was, at reasonable prices, an order book large enough to enable the plants to be operated practically at full capacity during the year. They continued every effort to maintain such an order book, and, in so far as they were a sheltered industry—in so far as, like other contractors to H.M. Government, they shared with them a large amount of work, for which, though, they competed keenly—they were at least relieved of competition from foreign countries employing cheaper labour and working longer hours, whose home markets were protected against British makers, and whose exports were subsidised both directly and indirectly. The limited protection to which he referred, however, did not apply to the general home or to the export trade. The forward policy of the directors in providing extensions of buildings and plant had been amply justified; indeed, but for the provision made they would have been in danger of being unable to maintain their manufacturing position.

European Iron and Steel Combine.—Following individual discussions between German, French, Belgian, Czecho-Slovak, Austrian, and Polish works, it is reported that a European iron and steel conference is to be held in the middle of June in Switzerland to regulate production and sales.

BLACKING,
PLUMBAGO,
CORE GUM,
WHITE DUST,
COAL DUST.

ESTABLISHED 1863

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—For very obvious reasons, interest in the Cleveland iron trade is rapidly approaching the vanishing point, and, although the markets are open as usual, actual business in buying and selling is now on an abnormally limited scale. Works on Tees-side are gradually closing down as stocks of fuel become exhausted, and unless large supplies of coals from foreign sources can be secured, the prevailing stagnation appears likely to continue indefinitely. As regards the pig-iron trade, there is still a disposition to place forward business, but makers are extremely cautious, in view of the great uncertainty as to what costs of production are likely to be when the strike is over. Prices continue to expand. Recently 2s. 6d. was added to the price of No. 3, and this week another 1s., making a total of 6s. per ton since the strike began. Quotations for home consumers are now :—No. 1, 79s. per ton ; No. 3 G.M.B., 76s. ; No. 4 foundry, 75s. ; and No. 4 forge, 74s. 6d. per ton.

There is still a small volume of business passing in East Coast hematite, and a few shipments are going abroad. But stocks are considerable, and sellers are not asking more than 78s. 6d. for mixed numbers and 79s. per ton for No. 1. On the North-West Coast prices are firm at the old rates. Bessemer mixed numbers being £4 2s. 6d. c.i.f. Welsh ports, £4 5s. 6d. to £4 7s. 6d. per ton delivered at Glasgow, £4 8s. to £4 10s. per ton delivered at Sheffield, and £4 15s to £4 16s. 6d. per ton delivered at Birmingham.

LANCASHIRE.—Consumers of foundry pig in this area are evidencing growing anxiety as to the possibility of obtaining supplies of this essential raw material, and although most of the furnaces offering in the local markets have fairly full order books, deliveries are now extremely difficult, with only limited stocks available. In recent markets makers have declined to quote, and in the circumstances prices are largely nominal at round 85s. per ton for Derbyshire No. 3 foundry pig, and 97s. 6d. for Scottish, delivered Manchester or equal distance.

THE MIDLANDS.—Increasing restriction of production at furnaces in South Staffordshire and the adjacent districts has practically exhausted stocks of No. 3 foundry irons, with very little left of other grades. Derbyshire No. 4 is offered at 72s. 6d., No. 1 at 77s. 6d., and Northants silky foundry at 70s. to 72s. 6d. per ton at furnaces. There is practically no North Staffordshire pig on offer at all. Owing to the scarcity of foundry numbers at the Midland furnaces, supplies have been ordered from the Cleveland district, and the price of this works out at 90s. to 91s. 6d. delivered station or siding this area.

SCOTLAND.—There are now only two furnaces in blast in this area, while the price of iron continues firm, and in some cases has been advanced 1s. to 1s. 6d. per ton, the general quotation for No. 3 foundry being 78s. f.o.t. furnaces. There has been little inquiry, but deliveries are going out fairly freely, in spite of the restricted railway facilities.

Metals.

Copper.—Movements in standard copper during the current week have disclosed few changes in the general position, with prices usually steady and occasionally tending to harder figures. There is probably a slight improvement in the Continental demand, and it is sincerely hoped that this will be the forerunner of something more substantial in this direction. Should this materialise there is a possibility of the market experiencing a more sound improvement than has been enjoyed for a considerable time.

Current quotations :—*Cash* : Thursday, £56 17s. 6d. ; Friday, £57 ; Monday, £57 10s. ; Tuesday, £57 10s. ; Wednesday, £57 7s. 6d.

Three Months : Thursday, £57 15s. ; Friday, £57 17s. 6d. ; Monday, £58 7s. 6d. ; Tuesday, £58 7s. 6d. ; Wednesday, £58 5s.

Tin.—The issue of the usual monthly statistics had an immediate adverse influence on standard tin, the increase in the total visible supply disclosed being much larger than anticipated, and the market has since had to withstand some heavy selling pressure.

Current quotations :—*Cash* : Thursday, £264 5s. ; Friday, £267 5s. ; Monday, £269 15s. ; Tuesday, £268 15s. ; Wednesday, £269 5s.

THE TECHNICAL EXHIBIT AT THE INTERNATIONAL FOUNDRY AND ALLIED TRADES' EXHIBITION.

Three Months : Thursday, £263 5s. ; Friday, £266 5s. ; Monday, £269 ; Tuesday, £268 12s. 6d. ; Wednesday, £268 15s.

Spelter.—In this section of the metal markets there has been surprisingly little disturbance of the general position, and although consumption is naturally much restricted by fuel supply difficulties, values have remained comparatively firm throughout the crisis. Offering from the Continent has not been on such a liberal scale as was the case some weeks ago, but it may be that if the present firmer tendency comes to an end producers will be anxious to unload some of their stocks again.

Current quotations : — *Ordinary* : Thursday, £33 7s. 6d. ; Friday, £33 10s. ; Monday, £33 18s. 9d. ; Tuesday, £34 1s. 3d. ; Wednesday, £33 15s.

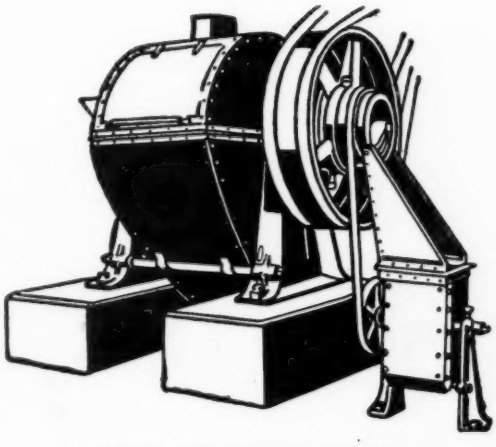
Lead.—The strength lately developed in the market for soft foreign pig, largely on account of German buying, has now given way, and values have lost much of their recent gain. The position as now recorded is probably much more representative, in view of the much smaller consumption due to the closing down of consumers' works in consequence of the industrial conditions. In fact, values would be much lower if stocks were not in strong hands.

Current quotations :—*Soft foreign (prompt)* :—Thursday, £29 13s. 9d. ; Friday, £30 2s. 6d. ; Monday, £30 12s. 6d. ; Tuesday, £30 17s. 6d. ; Wednesday, £31 3s. 9d.

Telegrams: "THROWER, GLASGOW." Telephone: 5909 CENTRAL.

ALBERT SMITH & Co FOUNDRY ENGINEERS. TOOLS & EQUIPMENT

Head Office: 60, St. ENOCH SQUARE, GLASGOW.



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BRASS RECOVERY MACHINES

are the last word in the Treatment of Brass Foundry

ASHES AND SKIMMINGS.

If you don't want to lose what your Competitor is saving, you must write to us about it now.

We are at your Service.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

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Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.
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Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

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J. GRAYSON LOWOOD & Co., Ltd.

DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	57	7	6
Three months ..	58	5	0
Electrolytic	65	0	0
Tough	62	0	0
Best selected ..	62	10	0
Sheets	90	0	0
India	74	0	0
Wire bars	65	10	0
Do. June–July ..	65	2	6
Do. July–August	65	2	6
Ingot bars	65	0	0
H.C. wire rods ..	69	10	0
Off. av. cash, May	56	11	1½
Do., 3 mths. May	57	8	10½
Do., Sttlmnt, May	56	10	4½
Do., Electro, May	64	10	10½
Do., B.S., May ..	60	14	4½
Aver. spot price copper, May ..	56	10	4½
Do., wire bars, May	64	15	6
Solid drawn tubes		12½	d.
Brazed tubes ..		12½	d.
Wire		9½	d.

BRASS.

Solid drawn tubes ..	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlld. ..	7½d.
Sheets to 10 w.g ..	10½d.
Wire	9½d.
Rolled metal	9½d.
Yellow metal rods ..	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets ..	8½d.

TIN.

Standard cash ..	269	5	0
Three months ..	268	15	0
English	267	5	0
Bars	268	15	0
Straits	277	15	0
Australian	270	5	0
Eastern	274	15	0
Banca	271	5	0
Off.aver. cash, May	270	5	0¾
Do., 3 mths., May	266	14	5½
Do., Sttlmt. May	270	4	9
Aver. spot., May	270	4	9

SPELTER.

Ordinary	33	15	0
Remelted	34	0	0
Hard	28	12	6
Electro 99.9 ..	37	7	6
English	34	15	0
India	31	7	6
Zinc dust	42	0	0
Zinc ashes	14	10	0
Off. aver., May ..	32	4	6
Aver., spot, May	32	0	9

LEAD.

Soft foreign ppt.	31	3	9
English	32	5	0
Off. average, May	28	9	8⅝
Average spot, May	28	5	0

ZINC SHEETS, &c.

Zinc sheets, English	41	0	0
Do. V.M. ex whf.	38	0	0
Rods	44	0	0
Boiler plates ..	38	10	0
Battery plates ..	38	0	0

ANTIMONY.

Special brands, Eng.	84	10	0
Chinese	60	0	0
Crude	40	0	0

QUICKSILVER.

Quicksilver ..	15	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon
25% 9 0 0
45/50% 11 5 0
75% 20 0 0

Ferro-vanadium—
35/40% 14/9 to 15/6lb. va.

Ferro-molybdenum—
70/75% c. free 6/– to 6/3 lb.

Ferro-titanium—
23/25% carbonless 11½d. lb.

Ferro-phosphorus, 20/25%, £17 0 0

Ferro-tungsten—
80/85%,c.fr. .. 1/7½ lb.

Tungsten metal powder—
98/99% .. 2/– to 2/1 lb.

Ferro-chrome—
2/4% car. .. £33 5 0
4/6% car. .. £22 5 0
6/8% car. .. £21 15 0
8/10% car. .. £20 15 0

Ferro-chrome—
Max. 2% car. £37 0 0
Max. 1% car. £43 10 0
Max.0.70%car. £54 10 0
70%,carbonless 1/5¼ lb.

Nickel—99%, cubes or pellets .. £170

Cobalt metal—98/99% 10/– lb.

Aluminium 98/99% £118

Metallic Chromium—
96/98% .. 3/3 lb.

Ferro-manganese (net)—
76/80%, loose £15 0 0
76/80%, packed £16 0 0
76/80%, export £14 5 0

Metallic manganese—
94/96%, carbonless 2/– lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten ..	2	6
Finished bars, 18% tungsten ..	3	0

Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. and over .. 4d.lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Do. under ¼in. to ⅛ in. .. .. 1/– lb.
Flats, ½in.×½in. to under 1 in.×⅛ in. 3d. lb.
Do. under ½in.×½in. 1/– lb
Bevels of approved sizes and sections 6d. lb.
Bars cut to length 10%extra

Scrap from high-speed tool steel—
Scrap pieces .. .. 3d.
Turnings and swarf 1d.
Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.
South Wales—			
Hvy. steel	3	7	6
Bundled steel & shrngs.	3 3 0 to 3	6	0
Mixed iron & steel	3 0 0 to 3	2	6
Heavy cast iron	3	5	0
Good machinery for foundries ..	3	5	0
Cleveland—			
Heavy steel ..	3	1	0
Steel turnings ..	2	6	0
Cast iron borings	2	5	0
Heavy forge ..	4	2	6
Bushelled scrap	3	10	0
Cast-iron scrap	3	7	6
Lancashire—			
Cast-iron scrap	3 2 6 to 3	10	0
Hvy. wrought ..	3	2	6
Steel turnings ..	2	2	0

London — Merchants' buying prices delivered yard.

Copper (clean)..	48	0	0
Brass (clean) ..	38	0	0
Lead (less usual draft)	27	0	0
Tea lead ..	22	0	0
Zinc	22	0	0
New aluminium cuttings ..	80	0	0
Braziery copper	44	0	0
Gunmetal ..	45	0	0
Hollow pewter	170	0	0
Shaped black pewter ..	126	0	0

PIG-IRON.

(*f.o.t. unless otherwise stated*).

N.E. Coast—
Foundry No. 1 .. 79/–
Foundry No. 3 .. 76/–
Foundry No. 4 .. 75/–
Forge No. 4 .. .. 74/6
Hematite No. 1 .. 79/–
Hematite M/Nos. .. 78/6

N.W. Coast—
Hem. M/Nos. d/d Glas. 86/6
„ d/d Birm. 95/9

Midlands—
Staffs. common* .. —
„ No. 4 forge .. —
„ No. 3 foundry —
Shrops. basic 70/–
„ Cold blast, ord.* 185/–
„ „ roll iron* .. 190/–
* d/d Birmingham.

Northants forge .. .. —
„ fdry No. 3 .. 71/3

Derbyshire forge .. —
„ fdry. No. 3 .. 76/3
„ basic .. .. .. —

Scotland—
Foundry No. 1 .. 83/–
„ No. 3 .. 78/–
Hem. M/Nos. 77/–

Sheffield (d/d district)—
Derby forge .. .. —
„ fdry. No. 3 .. 79/–
Lincs. forge 67/6
„ fdry. No. 3 .. 70/–
E.C. hematite 91/–
W.C. hematite .. 89/–

Lincs. (at furnaces)—
Forge No. 4 .. .. 61/6
Foundry No. 3.. .. 64/–
Basic 63/–

Lancashire (d/d eq. Man.)—
Derby forge .. .. —
„ fdry. No. 3 .. 85/–
Northants foundry No. 3 .. .. .. —
Dalzell, No. 3 .. .. 110/–
Summerlee, No. 3 .. 97/6
Glengarnock, No. 3 .. 97/6
Gartsherrie, No. 3 .. 97/6
Monkland No. 3 .. .. 97/6
Coltness, No. 3 .. .. 97/6
Shotts, No. 3 .. .. 97/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars(cr.)	11 0 0 to			12 0 0		
Angles				11 10 0		
Tees to 3 united ins.				12 0 0		
Nut and bolt	10 5 0 to			10 7 6		
Hoops	14 0 0 to			15 0 0		
Marked bars (Staffs.) f.o.t. ..				14 0 0		
Gas strip				12 10 0		
Bolts and nuts ½ in. × 4 in. ..				15 5 0		
Steel—						
Ship plates	7 12 6 to			7 17 6		
Boiler plts. ..				11 5 0		
Chequer plts. ..				9 15 0		
Angles				7 2 6		
Tees				8 2 6		
Joists				7 2 6		
Rounds and Squares 3 in. to 5½ ins. ..				8 0 0		
Rounds under 3 in. to ⅜ in.				7 15 0		
Flats, over 5 in. wide and up ..				8 10 0		
Flats, 5in. to 1½in.				7 10 0		
Rails, heavy ..				8 0 0		
Fishplates				12 0 0		
Hoops (Staffs.) ..				10 10 0		
Black sheets, 24g.				10 17 6		
Galv. cor. sheets, 24g.				16 0 0		
Galv. fencing wire 8g. plain				13 0 0		
Billets, soft ..				6 5 0		
Billets, hard ..				8 2 6		
Sheet bars	6 0 0 to			6 2 6		
Tin bars d/d	6 2 6 to			6 5 0		

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	3½
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

Per lb.
Ingots for raising 9d. to 1/3
Rolled—
To 9 in. wide 1/3 to 1/9
To 12 in. wide 1/3½ to 1/9½
To 15 in. wide 1/3½ to 1/9½
To 18 in. wide 1/4 to 1/10
To 21 in. wide 1/4½ to 1/10½
To 25 in. wide 1/5 to 1/11
Ingots for spoons and forks .. 9d. to 1/5½
Ingots rolled to spoon size .. 1/– to 1/8½
Wire round—
3/0 to 10 G. 1/6½ to 2/1½
with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated. Dols.

No. 2X foundry, Phila.	22.76
No. 2 foundry, Valley	19.76
No. 2 foundry, Birm.	22.00
Basic	19.76
Bessemer	20.76
Malleable	20.26
Grey forge	19.26
Ferro-mang. 80% d/d	88.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.85
Beams, etc.	1.90
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.50
Sheets, black, No. 28..	3.10
Sheets, galv., No. 28 ..	4.30
Sheets, blue an'l'd, 9 & 10	2.35
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry .. 32/6 to 40/–
„ furnace .. 20/– to 25/–
Durham & North.
„ foundry 30/– to 33/–
„ furnace 14/– to 14/6
Other Districts, foundry 30/– to 33/–
„ „ furnace (basis) 11/9

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box		20/–
„	28×20, „		40/–
„	20×10, „		30/–
„	18¾×14, „		21/–
C.W.	20×14, „		18/6
„	28×20, „		37/–
„	20×10, „		25/6
„	18¾×14, „		19/–

Terneplates 28×20, 36/6 per box basis f.o.b.

SWEDISH IRON.

Bars,hammered £18/10 to £19/0
Rolled Ord. £15/15/0 to £16/5/0
Nail rods £16 5 0 to £16 15 0
Keg. steel nom. £33 to £35
Faggot steel nom. £22 to £25
Blooms, according to quality £9 to £12
Pig-iron £6 5 0 to £7 0 0
all f.o.b. Gothenburg.

TUBES AND FITTINGS.
Up to and incl. 6 in.

	Tubes	*Fittings*
Gas	60%	50%
Water	55%	45%
Steam	50%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.		
June 10	56	17	6	inc.	5/–
,, 11	57	0	0	,,	2/6
,, 14	57	10	0	,,	10/–
,, 15	57	10	0	No change	
,, 16	57	7	6	dec.	2/6

Electrolytic Copper.

	£	s.	d.		
June 10	64	15	0	inc.	5/–
,, 11	64	15	0	No change	
,, 14	65	0	0	inc.	5/–
,, 15	65	0	0	No change	
,, 16	65	0	0	,,	,,

Standard Tin (Cash).

	£	s.	d.		
June 10	264	5	0	dec.	30/–
,, 11	267	5	0	inc.	60/–
,, 14	269	15	0	inc.	50/–
,, 15	268	15	0	dec.	20/–
,, 16	269	5	0	inc.	10/–

Tin (English ingots).

	£	s.	d.		
June 10	262	5	0	dec.	35/–
,, 11	265	0	0	inc	55/–
,, 14	267	10	0	inc.	50/–
,, 15	266	15	0	dec.	15/–
,, 16	267	5	0	inc.	10/–

Zinc Sheets (English).

	£	s.	d.		
June 10	41	0	0	No change	
,, 11	41	0	0	,,	,,
,, 14	41	0	0	,,	,,
,, 15	41	0	0	,,	,,
,, 16	41	0	0	,,	,,

Spelter (ordinary).

	£	s.	d.		
June 10	33	7	6	inc.	2/6
,, 11	33	10	0	,,	2/6
,, 14	33	18	9	,,	8/9
,, 15	34	1	3	,,	2/6
,, 16	33	15	0	dec.	6/3

Lead (English).

	£	s.	d.		
June 10	31	0	0	No change	
,, 11	31	10	0	inc.	10/–
,, 14	32	0	0	,,	10/–
,, 15	32	0	0	No change	
,, 16	32	5	0	inc.	5/–

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
1890	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 14 3	0 14 3	0 15 7½	0 15 7½	0 15 7½	0 15 2¾
1891	0 15 7½	0 14 2½	0 14 2½	0 14 2½	0 13 6½	0 13 6	0 13 3½	0 13 0	0 12 11	0 13 0	0 13 7	0 13 1	0 14 9½
1892	0 13 1	0 12 9	0 12 9	0 12 9	0 12 9	0 11 10½	0 12 1	0 12 1	0 12 2	0 12 0	0 12 0	0 11 11	0 12 4½
1893	0 11 11	0 11 5½	0 11 10	0 11 10	0 12 1½	0 12 3	0 12 1½	0 12 3	0 12 1	0 12 4½	0 12 4½	0 12 6	0 12 0½
1894	0 12 6	0 12 6	0 12 7½	0 12 1½	0 12 4	0 12 1	0 12 0	0 12 0½	0 11 10½	0 12 2	0 12 0	0 12 0	0 12 1½
1895	0 12 0	0 12 0	0 11 10	0 12 0	0 12 0	0 12 3	0 12 3	0 12 4	0 12 4	0 12 6	0 12 7	0 12 6	0 12 2½
1896	0 12 6	0 12 6	0 12 9	0 12 9	0 12 9	0 12 7	0 12 9	0 12 9	0 12 9	0 13 6	0 15 0	0 14 9	0 13 1
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 17 6	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 8½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7½
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8¼
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 8
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9¾
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 3½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 3 6	1 0 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 2 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 2½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 16 0	0 15 5½
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6½	1 1 3	1 1 5	1 0 9½
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 0 11½	0 19 6	0 19 0	0 19 0	0 19 1½	0 19 6	1 0 0½	1 1 6½	1 0 7½
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 2½
1913	1 2 9	1 2 2	1 1 7½	1 1 6	1 0 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 5½
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 5½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 3	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	} Price Fixed.												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17 6	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 13 8½
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 5 3	1 4 9½	1 4 2½	1 3 3½	1 2 6	1 2 3	1 5 2½
1923	1 2 9½	1 4 6½	1 5 2	1 4 8½	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 0	1 3 2½	1 4 9	1 3 10½
1924	1 4 2½	1 4 0	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	—	—	—	—	—	—	—	1 1 4

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